REMARKS

Claims 1-3, 5-22, 25, 26, 29, 30 and 33-34 are pending in this application.

Claims 11 and 19 have been allowed without the necessity of amendment. Claims 25, 29 and 33 have been conditionally allowed if rewritten in independent form to include all of the limitations of their respective base claims 1, 13 and 20. The Examiner's indication of allowability of these claims is noted with appreciation. For purposes of expedition, claims 25, 29 and 33 have been rewritten as independent claims to include substantially all of the limitations of their respective base claims 1, 13 and 20. As amended, claims 25, 29 and 33 are believed to be in condition for allowance. As for the remaining claims, forbearance is respectfully requested pending Applicants' traversal of the outstanding rejection of parent claims 1, 13 and 20.

Claims 1-3, 5-7, 10, 12-14, 17-18, 20 and 22 have been rejected under 35 U.S.C. §103 as being unpatentable over what the Examiner alleges as "Applicant admitted prior art" in view of Gunjima et al., U.S. Patent No. 5,587,816. In support of the rejection of independent claims 1, 13 and 20, the Examiner asserts that Applicants admitted prior art, as shown in FIGs. 32-35 of Applicants' disclosure, discloses a liquid crystal display device with all the claimed features, except for the feature:

> "a reflective polarizer arranged at an upper portion of the light control element so that a polarized light transmission axis of the

reflective polarizer is adjusted so as to be substantially perpendicular or substantially parallel to a control axis of the light control element."

The Examiner then cites column 5, lines 30-41 of Gunjima '816 for allegedly disclosing this feature in order to support a conclusion that "it would have been obvious ... to arrange such reflective polarizer in which the polarized light transmission axis of the reflective polarizer is adjusted so as to be substantially perpendicular or in parallel to the control axis of the light control element as claimed in claims 1, 13 and 20 for achieving maximum light transmittance and widen the viewing angle."

This rejection is respectfully traversed, however. Applicants respectfully submit that features of Applicants' independent claims 1, 13 and 20 are **not** disclosed or suggested in what the Examiner alleges as "Applicant admitted prior art" or Gunjima et al., U.S. Patent No. 5,587,816, whether taken individually or in combination with any other references of record. The cited column 5, lines 30-41 of Gunjima '816 does **not** disclose what the Examiner alleges. Therefore, Applicants respectfully request the Examiner to reconsider and withdraw this rejection for the following reasons.

First of all, as correctly identified by the Examiner, the common element that is critical to each of Applicants' independent claims 1, 13 and 20, that is **not** disclosed in what the Examiner alleges as "Applicant admitted prior art" (shown in FIGs. 32-35 of Applicants' disclosure), is the "<u>reflective polarizer</u>" that is "<u>arranged at an upper portion of the light control element so that a polarized light transmission</u>

<u>axis of the reflective polarizer is adjusted so as to be substantially perpendicular or substantially parallel to a control axis of the light control element</u>". In other words, the "polarized light transmission axis of the reflective polarizer [item 30, as shown in FIG. 5 and FIG. 20] must be adjusted substantially perpendicular or in parallel to the control axis of the light control element."

This feature is critical to Applicants' claimed invention because the polarized light conversion efficiency can be improved and the polarized light transmission rate can be increased by making the conversion axis of the optical path conversion element intersect perpendicularly with the polarized light transmission axis of the reflective polarizer. Such reasons are expressly described on page 29, line 13 extending to page 30, line 25 of Applicants' substitute specification. Simply, the polarized light conversion **cannot** be obtained or achieved by the conventional LCD device shown in FIGs. 32-35 of Applicants' background of the disclosure. In fact, the very deficiencies in the conventional LCD device shown in FIGs. 32-35 of Applicants' background of the disclosure, such as the inability to perform polarized light conversion efficiently because linear polarized light polarized by bireflingence of light control element is converted to ellipsoidal polarized light, as solely identified by Applicants, are the basis for Applicants' invention, that is, to solve the above defects by setting "a polarized light transmitting axis of the reflective type polarizer substantially perpendicular or parallel to the conversion axis of the light control element" as expressly defined in each of Applicants' independent claims 1, 13 and 20. In addition, the light control element [which is an anisotropic medium] is

arranged between the illumination device and the reflective polarizer in order to increase the transmittance of light of the display. As a result, a thin LCD providing a bright display can be realized.

The noted deficiencies of what the Examiner alleges as "Applicant admitted prior art", as shown in FIGs. 32-35 of Applicants' disclosure, are **not** and **cannot** be remedied by the cited column 5, lines 30-41 of Gunjima '816.

Specifically, Gunjima '816, as a secondary reference, simply discloses an illumination device provided with a direct viewing type display element. A polarized light separating sheet is used to project p-polarized light efficiently. However, there is **no** disclosure anywhere in Gunjima '816 of Applicants' claimed "reflective polarizer arranged at an upper portion of the light control element so that a polarized light transmission axis of the reflective polarizer is adjusted so as to be substantially perpendicular or substantially parallel to a control axis of the light control element" as defined in each of independent claims 1, 13 and 20.

Gunjima '816, at column 5, lines 30-41, only discloses that,

> "it is preferable that the polarizing sheeting provided on the light-incident side of the liquid crystal display element, is disposed such that the transmittance thereof is maximized with respect to the p polarized light component which is emitted from the polarized light separator, for employing the illumination device as the backlight of the liquid crystal display element. That is, **an average direction of an optical axis of polarization of a light ray emitted from the flat light guide in the flat illumination device approximately agrees with the optical axis of polarization of the polarizing sheet on the light-incident side of the liquid crystal display element**."

Evidently, the Examiner argues on pages 10-11 of the Office Action (Paper No. 22) that, because Gunjima '816 describes "the average direction of an optical axis of polarization of a light ray emitted from the flat light guide in the flat illumination device approximately agrees with the optical axis of polarization of the polarizing sheet on the light-incident side of the liquid crystal display element", such a description can be interpreted or speculated as the polarized light transmission axis of the reflective polarizer approximately in parallel to a major axis direction of pixel of the liquid crystal display element, and that the "polarized light transmission axis of the reflective polarizer must be adjusted substantially perpendicular or in parallel to the control axis of the light control element so as to obtain a maximized transmittance."

However, this line of argument is factually incorrect and legally improper. Either the cited column 5, lines 30-41, Gunjima '816, discloses or does **not** disclose Applicants' claimed "reflective polarizer arranged at an upper portion of the light control element so that a polarized light transmission axis of the reflective polarizer is adjusted so as to be substantially perpendicular or substantially parallel to a control axis of the light control element" as defined in each of independent claims 1, 13 and 20. There is **no** basis for speculation or interpretation. Again, there is **no** basis anywhere in Gunjima '816 to support the Examiner's assertion that the polarized light transmission axis of the reflective polarizer must be adjusted so as to be substantially perpendicular or substantially parallel to a control axis of the light control element.

The law under 35 U.S.C. §103 is well settled that "obviousness cannot be established by combining the teachings of the prior art to produce the claimed invention, absent some teaching, suggestion or incentive supporting the combination." ACS Hospital System, Inc v. Montefiore Hospital, 732 F.2d 1572, 1577, 221 USPQ 929, 933 (Fed. Cir. 1984). The Examiner must point to something in the prior art that suggests in some way a modification of a particular reference or a combination of references in order to arrive at Applicants' claimed invention. Absent such a showing, the Examiner has improperly used Applicants' disclosure as an instruction book on how to reconstruct to the prior art to arrive at Applicants' claimed invention. Of course, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and **not** based on Applicants' disclosure. In re Vaeck, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991). See MPEP 2143. In other words, all the claim limitations must be taught or suggested by the prior art. In re Royka, 490 F.2d 981, 180 USPQ 580 (CCPA 1974). "All words in a claim must be considered in judging the patentability of that claim against the prior art." In re Wilson, 424 F.2d 1382, 1385, 165 USQP 494, 496 (CCPA 1970).

Again, as previously pointed out, the Examiner has ignored to treat the claim invention as a whole, misinterpreted the disclosure of Gunjima '816, and incorrectly employed impermissible hindsight reconstruction to incorporate Gunjima '816 into what the Examiner alleges as "Applicant admitted prior art", failed to provide any

suggestion or motivation in the references themselves to modify Gunjima '816 into what the Examiner alleges as "Applicant admitted prior art" in order to arrive at Applicants' claims 1, 13 and 20.

Separately, Applicants' independent claim 20 further defines at least another feature that has not been addressed by the Examiner and that is not disclosed or suggested anywhere in the Examiner's proposed combination, that is, "<u>a liquid crystal display element for controlling polarization of projected light projected from the reflective polarizer so that a major axis direction of a pixel of the liquid crystal display element is arranged approximately parallel to a direction in which a linearly polarized light component of the polarized light projected from the illumination device is high</u>."

In view of the foregoing deficiencies of the Examiner's proposed combination and the explanations provided above, Applicants respectfully request that the rejection of claims 1-3, 5-7, 10, 12-14, 17-18, 20 and 22 be withdrawn.

Claims 8, 15, 21, 26, 30 and 34 have been rejected under 35 U.S.C. §103 as being unpatentable over what the Examiner alleges as "Applicant admitted prior art" and Gunjima et al., U.S. Patent No. 5,587,816 as applied to claims 1-3, 5-7, 10, 12-14, 17-18, 20 and 22, further in view of Yuuki et al., U.S. Patent No. 6,147,725 for reasons stated on pages 7-8 of the Office Action (Paper No. 22). Applicants respectfully traverse this rejection for the same reasons discussed against the rejection of claims 1-3, 5-7, 10, 12-14, 17-18, 20 and 22, and also noting that Yuuki '725 does **not** qualify as prior art against Applicants' claims 8, 15, 21, 26, 30 and 34.

This is because Applicants' claimed priority to an earlier JP application No. 10-68128 filed on March 18, 1998 predates the filing date of October 20, 1998 of Yuuki '725. Copies of the JP priority document and its certified English translation of the same document are enclosed as **Exhibit A** and **Exhibit B** as attached herewith for the Examiner's consideration and entry. In view of these submissions, Applicants respectfully request that the rejection of claims 8, 15, 21, 26, 30 and 34 be withdrawn.

Lastly, claims 9 and 16 have been rejected under 35 U.S.C. §103 as being unpatentable over what the Examiner alleges as "Applicant admitted prior art" and Gunjima et al., U.S. Patent No. 5,587,816 as applied to claims 1-3, 5-7, 10, 12-14, 17-18, 20 and 22, further in view of Wortman et al., U.S. Patent No. 6,101,032 for reasons stated on pages 8-9 of the Office Action (Paper No. 22). Since the correctness of this rejection is predicated upon the correctness of the rejection of claims 1-3, 5-7, 10, 12-14, 17-18, 20 and 22, Applicants respectfully traverse the rejection primarily for the same reasons discussed against the rejection of claims 1-3, 5-7, 10, 12-14, 17-18, 20 and 22.

In view of the foregoing amendments, arguments and remarks, all claims are deemed to be allowable and this application is believed to be in condition to be passed to issue. Should any questions remain unresolved, the Examiner is requested to telephone Applicants' attorney at the Washington DC area office at (703) 312-6600.

INTERVIEW:

In the interest of expediting prosecution of the present application, Applicants respectfully request that an Examiner interview be scheduled and conducted. In accordance with such interview request, Applicants respectfully request that the Examiner, after review of the present Amendment, contact the undersigned local Washington, D.C. area attorney at the local Washington, D.C. telephone number (703) 312-6600 for scheduling an Examiner interview, or alternatively, refrain from issuing a further action in the above-identified application as the undersigned attorneys will be telephoning the Examiner shortly after the filing date of this Amendment in order to schedule an Examiner interview. Applicants thank the Examiner in advance for such considerations. In the event that this Amendment, in and of itself, is sufficient to place the application in condition for allowance, no Examiner interview may be necessary.

Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, or credit any overpayment of fees, to the

deposit account of Antonelli, Terry, Stout & Kraus, LLP, Deposit Account No. 01-2135 (503.36984X00).

Respectfully submitted,

ANTONELLI, TERRY, STOUT & KRAUS, LLP

Hung H. Bui

Hung H. Bui
Registration No. 40,415

HHB/slh
(703) 312-6600

EXHIBIT A

【書類名】　明細書

【発明の名称】　カラー液晶表示装置

【特許請求の範囲】

【請求項1】

一対の透明基板間に液晶層を挟持し、該液晶層の配向状態を制御する電界印加手段を設け、該透明基板の出射側基板に吸収型偏光選択手段を配置した液晶表示素子と該液晶表示素子の背面に照明装置を配置した液晶表示装置において、該一対の透明基板の出射側基板に光拡散手段と該入射側基板に反射型色選択手段と反射型偏光選択手段とを具備し、該液晶表示素子の背面に平行度の高い光を照射し、該反射型色選択手段及び該反射型偏光手段からの反射光を反射する反射手段を配置した照明装置を具備したことを特徴とするカラー液晶表示装置。

【請求項2】

一対の透明基板間に液晶層を挟持し、該液晶層の配向状態を制御する電界印加手段を設け、該透明基板の出射側基板に吸収型偏光選択手段を配置した液晶表示素子と該液晶表示素子の背面に照明装置を配置した液晶表示装置において、該一対の透明基板の出射側基板に光拡散手段と該入射側基板に反射型偏光選択手段とストライプ状の反射型色選択手段とを具備し、該液晶表示素子の背面に該反射型色選択手段のストライプ方向に略直交する方向には少なくても指向性を有し該反射型色選択手段及び該反射型偏光手段からの反射光を反射する反射手段を配置した照明装置を具備し、該光拡散手段が少なくても一軸方向には拡散性を有し、該光拡散手段の拡散軸方向と該照明装置の指向性を有する方向とが交差することを特徴とするカラー液晶表示装置。

【請求項3】

一対の透明基板間に液晶層を挟持し、該液晶層の配向状態を制御する電界印加手段を設け、該透明基板の出射側基板に吸収型偏光選択手段を配置した液晶表示素子と該液晶表示素子の背面に照明装置を配置した液晶表示装置において、該一対の透明基板の出射側基板に光拡散手段と該入射側基板に反射型偏光選択手段とストライプ状の反射型色選択手段とを具備し、該液晶表示素子の背面に該反射型色選択手段のストライプ方向に略直交する方向には少なくても指向性を有し該反

射型色選択手段及び該反射型偏光選択手段からの反射光を反射する反射手段を配置した照明装置を具備し、該光拡散手段が少なくても一軸方向には拡散性を有し、該光拡散手段の拡散軸方向と該照明装置の指向性を有する方向とが略直交することを特徴とするカラー液晶表示装置。

【請求項４】

請求項１乃至３において、少なくてもある方位における照明装置からの出射光半値幅θ_1（ピーク輝度の１／２になる角度範囲）が前記透明基板の厚み、屈折率をそれぞれｔ，ｎとし、前記液晶表示素子のドット短辺の長さをｄとすると、下式の関係を満足することを特徴とするカラー液晶表示装置。

【数１】

$$\theta_1 \leq \sin^{-1}\left(n\sin\left(\tan^{-1}\left(\frac{2d}{t}\right)\right)\right) \quad \cdots (1)$$

【請求項５】

請求項１乃至４において、該一対の透明基板の入射側基板に第２の吸収型偏光選択手段を具備したことを特徴とするカラー液晶表示装置。

【請求項６】

請求項２乃至５において、少なくても該反射型色選択手段のストライプ方向には視野角が広い方向になるように該液晶層、該反射型偏光選択手段、該吸収型偏光選択手段、該反射型色選択手段を配置したことを特徴とするカラー液晶表示装置。

【請求項７】

請求項２乃至６において、少なくても該照明装置の光導光体が裏面に微細な溝を有する一軸方向に指向性を有することを特徴とするカラー液晶表示装置。

【請求項８】

請求項２乃至７において、該照明装置がサイドライト方式でランプの長軸方向と該反射型色選択手段のストライプ方向が略平行であることを特徴とするカラー液晶表示装置。

【請求項９】

請求項１乃至８において、該照明装置上に少なくても一軸方向に指向性を有する配光制御手段を有することを特徴とするカラー液晶表示装置。

【請求項１０】

請求項１乃至９において、該透明基板の一方に吸収型色選択手段を具備することを特徴とするカラー液晶表示装置。

【請求項１１】

請求項１乃至１０において、該液晶層が略９０度捩じれたツイストネマチック液晶層で、ノーマリーホワイト表示モードになるように該吸収型偏光選択手段と該反射型偏光選択手段とを配置したことを特徴とするカラー液晶表示装置。

【請求項１２】

請求項１乃至１０において、該液晶層が該電界印加手段によりホモジニアス配向とホメオトロピック配向を制御できる液晶層であることを特徴とするカラー液晶表示装置。

【請求項１３】

請求項１乃至１０において、該電界印加手段により該一対の透明基板に平行に電界を印加することを特徴とするカラー液晶表示装置。

【請求項１４】

請求項１乃至１３において、該光拡散手段が該吸収型偏光選択手段の内側に配置され偏光を維持することを特徴とするカラー液晶表示装置。

【請求項１５】

請求項１乃至１４において、少なくても該反射型偏光選択手段又は該反射型色選択手段のどちらかに偏光の透過と反射とを制御する誘電体多層膜が含まれることを特徴とするカラー液晶表示装置。

【請求項１６】

請求項１乃至１４において、少なくても該反射型偏光選択手段又は該反射型色選択手段のどちらかに偏光の透過と反射とを制御するコレステリック液晶層が含まれることを特徴とするカラー液晶表示装置。

【請求項１７】

一対の透明基板間に液晶層を挟持し、該液晶層の配向状態を制御する電界印加手段を設け、該透明基板の出射側基板に吸収型偏光選択手段を配置した液晶表示素子と該液晶表示素子の背面に照明装置を配置した液晶表示装置において、該一対の透明基板の出射側基板に光拡散手段と該入射側基板に反射型偏光選択手段とストライプ状の反射型色選択手段とを具備し、該液晶表示素子の背面に該反射型色選択手段のストライプ方向に略直交する方向には少なくても指向性を有し該反射型色選択手段及び該反射型偏光選択手段からの反射光を反射する反射手段を配置した照明装置を具備し、該光拡散手段が少なくても一軸方向には拡散性を有し、該光拡散手段の拡散軸方向と該照明装置の指向性を有する方向とが略直交し、該液晶表示素子の広視野角方向と該反射型色選択手段のストライプ方向とが略一致するように該液晶表示素子を配置したことを特徴とするカラー液晶表示装置。

【請求項１８】

一対の透明基板間に液晶層を挟持し、該液晶層の配向状態を制御する電界印加手段を設け、該透明基板の出射側基板に吸収型偏光選択手段を配置した液晶表示素子と該液晶表示素子の背面に照明装置を配置した液晶表示装置において、該一対の透明基板の出射側基板に光拡散手段と該入射側基板に第２の吸収型偏光選択手段と反射型偏光選択手段とストライプ状の反射型色選択手段とを具備し、該液晶表示素子の背面に該反射型色選択手段のストライプ方向に略直交する方向には少なくても指向性を有し該反射型色選択手段及び該反射型偏光選択手段からの反射光を反射する反射手段を配置した照明装置を具備し、該光拡散手段が少なくても一軸方向には拡散性を有し、該光拡散手段の拡散軸方向と該照明装置の指向性を有する方向とが略直交し、該液晶表示素子の広視野角方向と該反射型色選択手段のストライプ方向とが略一致するように該液晶表示素子を配置したことを特徴とするカラー液晶表示装置。

【請求項１９】

一対の透明基板間に液晶層を挟持し、該液晶層の配向状態を制御する電界印加手段を設け、該透明基板の出射側基板に吸収型偏光選択手段を配置した液晶表示素子と該液晶表示素子の背面に照明装置を配置した液晶表示装置において、該一

対の透明基板の出射側基板に光拡散手段と該入射側基板に第２の吸収型偏光選択手段と反射型偏光選択手段とストライプ状の反射型色選択手段とを具備し、該透明基板の一方に該反射型色選択手段の配置と略一致した配置の吸収型色選択手段を具備し、該液晶表示素子の背面に該反射型色選択手段のストライプ方向に略直交する方向には少なくても指向性を有し該反射型色選択手段及び該反射型偏光選択手段からの反射光を反射する反射手段を配置した照明装置を具備し、該光拡散手段が少なくても一軸方向には拡散性を有し、該光拡散手段の拡散軸方向と該照明装置の指向性を有する方向とが略直交し、該液晶表示素子の広視野角方向と該反射型色選択手段のストライプ方向とが略一致するように該液晶表示素子を配置したことを特徴とするカラー液晶表示装置。

【請求項２０】

一対の透明基板間に液晶層を挟持し、該液晶層の配向状態を制御する電界印加手段を設け、該透明基板の出射側基板に吸収型偏光選択手段を配置した液晶表示素子と該液晶表示素子の背面に照明装置を配置した液晶表示装置において、該一対の透明基板の出射側基板に光拡散手段と該入射側基板に第２の吸収型偏光選択手段と反射型偏光選択手段とストライプ状の反射型色選択手段とを具備し、該液晶表示素子の背面に該反射型色選択手段のストライプ方向に略直交する方向には少なくても指向性を有し該反射型色選択手段及び該反射型偏光選択手段からの反射光を反射する反射手段を配置した照明装置を具備し、該光拡散手段が該吸収型偏光選択手段の内側に配置され偏光を維持し、少なくても一軸方向には拡散性を有し、該光拡散手段の拡散軸方向と該照明装置の指向性を有する方向とが略直交し、該液晶表示素子の広視野角方向と該反射型色選択手段のストライプ方向とが略一致するように該液晶表示素子を配置したことを特徴とするカラー液晶表示装置。

【請求項２１】

一対の透明基板間に液晶層を挟持し、該液晶層の配向状態を制御する電界印加手段を設け、該透明基板の出射側基板に吸収型偏光選択手段を配置した液晶表示素子と該液晶表示素子の背面に照明装置を配置した液晶表示装置において、該一対の透明基板の出射側基板に光拡散手段と該入射側基板に第２の吸収型偏光選択

手段と反射型偏光選択手段とストライプ状の反射型色選択手段とを具備し、該透明基板の一方に該反射型色選択手段の配置と略一致した配置の吸収型色選択手段を具備し、該液晶表示素子の背面に該反射型色選択手段のストライプ方向に略直交する方向には少なくても指向性を有し該反射型色選択手段及び該反射型偏光選択手段からの反射光を反射する反射手段を配置した照明装置を具備し、該光拡散手段が該吸収型偏光選択手段の内側に配置され偏光を維持し、少なくても一軸方向には拡散性を有し、該光拡散手段の拡散軸方向と該照明装置の指向性を有する方向とが略直交し、該液晶表示素子の広視野角方向と該反射型色選択手段のストライプ方向とが略一致するように該液晶表示素子を配置したことを特徴とするカラー液晶表示装置。

【請求項２２】

一対の透明基板間に略９０度捩れたツイステッドネマチック液晶層を挟持し、該液晶層の配向状態を制御する電界印加手段を設け、該透明基板の出射側基板に吸収型偏光選択手段を配置した液晶表示素子と該液晶表示素子の背面に照明装置を配置した液晶表示装置において、該一対の透明基板の出射側基板に光拡散手段と該入射側基板に第２の吸収型偏光選択手段と反射型偏光選択手段とストライプ状の反射型色選択手段とを具備し、該透明基板の一方に該反射型色選択手段の配置と略一致した配置の吸収型色選択手段を具備し、該液晶表示素子の背面に該反射型色選択手段のストライプ方向に略直交する方向には少なくても指向性を有し該反射型色選択手段及び該反射型偏光選択手段からの反射光を反射する反射手段を配置した照明装置を具備し、該光拡散手段が該吸収型偏光選択手段の内側に配置され偏光を維持し、少なくても一軸方向には拡散性を有し、該光拡散手段の拡散軸方向と該照明装置の指向性を有する方向とが略直交し、該液晶表示素子の広視野角方向と該反射型色選択手段のストライプ方向とが略一致するように該液晶表示素子を配置したことを特徴とするカラー液晶表示装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】

本発明は、偏光変換，波長選択性を利用した光の再利用によるカラー液晶表示

装置に関する。特に、カラー液晶表示素子の背面に照明装置を配置した透過型カラー液晶表示装置に関する。

【０００２】

【従来の技術】

近年、液晶表示装置、特にカラー液晶表示装置の技術進歩は、目覚ましく、ＣＲＴに劣らぬ表示品質のディスプレイが数多く見られるようになった。更に、ノートパソコンが普及し、照明装置としてバックライト無しでは、ディスプレイとしての体をなさず、バックライトは直視型カラー液晶表示装置における必須デバイスである。

【０００３】

現在、市場を占める直視型カラー液晶表示装置は、大別してＴＦＴ（薄膜トランジスタ）を用いたアクティブマトリクス駆動による液晶表示装置とマルチプレックス駆動のＳＴＮ（スーパーツイステッドネマチック）液晶表示装置との２方式がある。いずれも液晶層をガラス基板で保持した素子の両側に偏光板を配置し、直線偏光の偏光状態を変調して表示を行うものである。ＴＦＴを用いた液晶表示装置には代表的なＴＮ（ツイストネマチック）方式，それ以外の方式にＶＡＮ（垂直配向ネマチック液晶）方式，ＩＰＳ（横電界）方式等様々な方式が用いられている。上記２方式は、照明装置上に配置され照明装置からの透過光の偏光を制御して画像表示を行う。カラー液晶表示装置の光損失を見積ると、偏光板による光損失は、６０％程度である。また、カラー表示を行う場合、面分割したカラーフィルタを配置した表示装置では、カラーフィルタの損失は７０％以上ある。この偏光板、カラーフィルタにより８８％程度の光が損失となっている。従って、他の損失を排除しても偏光板及びカラーフィルタによる吸収損失で、照明装置からの出射光のうち高々１２％程度しか利用できないことになる。しかしながら、ノートパソコン用の液晶ディスプレイである液晶表示装置に対する要求は、薄型，軽量のみならず、低消費電力で高輝度の表示である。更に、デスクトップコンピュータやワークステーション等のディスプレイとして低消費電力化の要求も高い。従って、液晶ディスプレイに対する低消費電力化は、至上命題の一つである。

【０００４】

これに対して、偏光板，カラーフィルタによる吸収損失を無くし、明るさ向上を実現するための技術が、特開平6－130424 号，特開平6－167718 号に開示されている。この技術は、特定波長の光を効率良く利用するために、特定波長の所定方向円偏光の反射・透過をコレステリック液晶層により制御して、反射光を再利用することにより光利用効率向上を行うものである。

【０００５】

【発明が解決しようとする課題】

特開平6－130424 号公報，特開平6－167718 号公報においては、それぞれ色選択層を基板の外側及び内側に配置する構成が開示されている。開示技術の構成を図３０，図３１に示す。図３０は、ガラス基板１０１，１０４間に液晶１０３を挟持し出射側に選択層１００，入射側に色選択層であるコレステリック層１０６及びフィルタ層１０５を配置しており、コレステリック層１０６の裏面に光源１０７及び反射板１０８を配置した構造である。しかしながら、光源の特性等については何ら触れられていない。従って、図３０のように色選択層であるコレステリック層１０６がガラス基板１０４の外部に配置された構成の場合、正面から見た出射光１１０は、コレステリック層１０６と液晶１０３が同一のドット（同一の色を表示する領域）を透過するために、表示色に混色等の問題が生じない。しかしながら、斜め方向から見た場合の斜め出射光１０９は、例えば赤（又は緑，青）の色選択層１０６を透過した光が、隣のドットである緑（又は青）の変調信号で透過光が制御されることになる。従って、斜めから見た場合、基板１０４の厚み（通常ガラス基板の厚みは１．１mm又は０．７mm、ドットピッチは１００μm程度）のために、見る角度により正しい色が表示されないことになる。

【０００６】

一方、このガラス基板１０４の厚みの影響を無くすために、図３１に示すように色選択層１１２及び位相差板１１１を内蔵した構造も開示されている。その他の構成は図３０と同様である。しかしながら、光源の特性に絡む斜め入射に対する問題については何ら触れられていない。公知例に開示されている図３１の構成では、色選択層１１２と位相差板１１１により液晶層１０３への偏光状態を制御

し、その偏光状態を液晶層１０３で制御して表示を行っている。しかしながら、色選択層１１２に用いているコレステリック液晶層は斜め入射に対して偏光度が悪いばかりか、不必要な色の光漏れを生じる。つまり、斜め入射に対しては、所望の偏光以外の偏光及び、所望の色以外の色に漏れを生じ、コントラスト比，色再現性，視野角特性の低下で代表される表示品質劣化を招く。

【０００７】

そこで、本発明の目的は、偏光板・カラーフィルタによる吸収損失を無くし、光利用効率の向上を目指すものであるが、従来技術では問題であったガラス基板の厚みによる画質の劣化（不鮮明さ）及び、斜め方向での画質の劣化（コントラスト比低下，表示色の劣化）を排除し、斜め方向から見た場合でも表示品質の高い広視野角のカラー液晶表示装置を得ることにある。

【０００８】

本発明の他の目的は、後述の実施例の説明から明らかになろう。

【０００９】

【課題を解決するための手段】

上記目的を達成するために本発明では以下の手段を用いる。一対の透明基板間に液晶層を挟持し、該液晶層の配向状態を制御する電界印加手段を設け、該透明基板の出射側基板に吸収型偏光選択手段を配置した液晶表示素子と該液晶表示素子の背面に照明装置を配置した液晶表示装置において、該一対の透明基板の出射側基板に光拡散手段と該入射側基板に反射型色選択手段と反射型偏光選択手段とを具備し、該液晶表示素子の背面に平行度の高い光を照射し、該反射型色選択手段及び該反射型偏光手段からの反射光を反射する反射手段を配置した照明装置を具備したことを特徴とするカラー液晶表示装置である。

【００１０】

まず、上記手段の個々の作用について説明する。電界印加手段は、該液晶層の配向状態を制御するための電極及び電極に電圧を印加する回路等から構成され、電界印加手段により液晶層の配向状態を制御し、液晶層を透過する偏光の偏光状態を制御することにより表示を行う。吸収型偏光選択手段は、例えば直交する一方の直線偏光を透過し、他方の直線偏光を吸収する不要偏光を吸収する所謂直線

偏光板、または、二つの円偏光の内一方を透過し、他方の円偏光を吸収する不要偏光を吸収する所謂円偏光板である。反射型偏光選択手段は、例えば直交する一方の直線偏光を透過し、他方の直線偏光を反射する不要偏光を反射する直線偏光板、または、二つの円偏光の内一方を透過し、他方の円偏光を反射する不要偏光を反射する円偏光板である。反射型色選択手段は、ある波長領域（例えば中心波長５５０ｎｍに対し±４０ｎｍ程度）の直線偏光（又は円偏光）を透過し、他の波長領域の直線偏光（又は円偏光）を反射する不要波長領域の光を反射する所謂カラーフィルタである。詳細は、実施例から明らかになるが、コレステリックの特性反射や誘電体多層膜の特性を利用したものである。光拡散手段は、光拡散手段への入射光を拡散する例えば、ホログラムや屈折率の不均一性を有する散乱媒体であり、好ましくは偏光を維持するものであり、照明装置からの平行度の高い光を液晶表示素子の出射側を広げることにより広視野角化を果たす役割を示すものである。照明装置とし出射光の平行度を高める手段として、例えば、裏面にストライプ状の微細溝を有する楔型の導光体及び導光体上にストライプ溝とは直交するストライプ状の三角形状を有するレンズシートを配置する。これにより、導光体のストライプ微細溝によりストライプ方向に垂直方向には平行度の高い出射光が得られ、更に、レンズシートによりそれに直交する方向にも平行度を高めることができる。全方位に平行度の高い照明装置を得ることができる。その他の平行光化手段は実施例より明らかになるであろう。

【００１１】

照明装置の平行度が悪い場合、画像の不鮮明さ，混色が生じる問題は、図３０，図３１の公知例で示した通りであるが、照明装置の平行度が鮮明な画像を得るためには重要になる。図３２の液晶表示素子を用いて、光源の必要な平行度について検討した。まず、本発明では、出射側に吸収型偏光選択層１０，光拡散層１１を配置した透明基板１２，１４間に液晶層１３を配置し、入射側に反射側色選択層３０である位相差板１６及びコレステリック層１７を配置した構造である。透明基板１２，１４の厚み１２ｔ，１４ｔを共にｔ、ドットピッチ１３Ａをｄ、液晶表示素子４０への入射光の入射角度１３０をθ_1、透明基板１４への入射角度１３１をθ_2、透明基板１２，１４の屈折率をｎとする。ここで、画素は

ＲＧＢの３ドットで１画素となり、１ドットは通常縦横比３：１であり、１ドットの短辺をドットピッチｄとした。また、斜め入射における透明基板の厚みによる混色，不鮮明さは、ピーク輝度の１／２になる輝度の角度において、少なくても２ドット分以内に収めないと画像が不鮮明になる。従って、入射光の入射角度θ_1は、下記を満足しなければならない。

【００１２】

【数２】

$$\theta_1 \leq \sin^{-1}\left(n\sin\left(\tan^{-1}\left(\frac{2d}{t}\right)\right)\right) \quad \cdots (1)$$

【００１３】

透明基板の屈折率ｎ＝１．５３　，厚みｔ＝７００μｍ，ドットピッチｄ＝100μｍとすると、入射光の入射角θ_1は、２４．９°以下でなければ、入射光が他の色のドットと重なり、混色，不鮮明さ等の画質低下を招く。従って、照明装置の平行度としては少なくて半値幅（ピーク輝度の１／２になる輝度の角度範囲）で（１）を満足す角度範囲にする必要があり、本実施例で使用した透明基板，画素においては、２４．９°以下が必要である。

【００１４】

次に、反射型色選択手段３０，反射型偏光選択手段３１の作用について図２を用いて詳細に説明する。反射型色選択手段３０の一例として、コレステリックの特性反射を利用したコレステリック層１７Ａ～１７Ｃと各波長に対して１／４波長として作用する位相差板１６を用いる。この位相差板１６は、各色において１／４波長として作用するようにコレステリック層１７同様に各色毎に配置されていても良い。反射型偏光選択手段３１として例えば、少なくても３原色に対して特性反射を有するコレステリック層１８Ａを用い、コレステリック層１７Ａ～１７Ｃとは逆ねじりの層とする。反射型色選択手段３０としてのコレステリック層１７Ａ～１７Ｃと位相差板１６及び反射型偏光選択手段３１としてのコレステ

リック層１８Ａを導光手段２２と反射手段２１からなる照明装置上に配置する。

この反射型偏光選択手段３１としてのコレステリック層１８Ａを用いることは既知であり、特開平3－45906号公報，特開平6－324333 号公報に開示された技術を適用することができる。コレステリック層による特性反射波長λ＝（ｎｏ＋ｎｅ）／２Ｐはコレステリックの螺旋ピッチＰ，材料ので常方向ｎｏ，異常方向屈折率ｎｅで決まり、特性反射帯域Δλ＝ΔｎＰは、屈折率異方性Δｎ＝ｎｅ－ｎｏと螺旋ピッチＰで決まる。しかしながら、Δｎは高々０．３ 程度であり全可視域をカバーすることができないため、異なるピッチのコレステリック層を積層あるいは、コレステリック層内でピッチを変化させて対応する。また、反射型色選択手段３０としてのコレステリック層１７Ａ～１７Ｃは、反射型偏光選択手段３１と同様の材料を用いることができ、赤，緑，青の特性反射をするようにそれぞれの層の螺旋ピッチを設定する。特性反射中心波長，特性反射帯域は限定されないが、それぞれの中心波長を４７０ｎｍ，５５０ｎｍ，６２０ｎｍとし、特性反射帯域を±３５ｎｍ程度が好ましい。

【００１５】

説明の都合上、コレステリック層１７Ａ～１７Ｃは右捩じれ、コレステリック層１８Ａは左捩じれとする。従って、コレステリック層１８Ａは、可視領域で左円偏光を反射し、右円偏光を透過する。また、コレステリック層１７Ａ，１７Ｂ，１７Ｃはそれぞれ、赤色の右円偏光，緑色の右円偏光，青色の右円偏光を反射し、それ以外の色を透過する。

【００１６】

透明アクリル樹脂からなる導光手段２２からの白色無偏光である出射光２００は、反射型偏光選択手段であるコレステリック層１８Ａに入射し、透過光は白色の右円偏光２０１に反射光は白色の左円偏光２０３となる。透過光である白色の右円偏光２０１は、コレステリック層１７Ａ，１７Ｃに入射し、緑色の右円偏光２０２が透過し、青色，赤色の右円偏光２０６は反射される。また、透過した緑色の右円偏光は位相差板１６により緑色の直線偏光２１３になる。

【００１７】

一方、反射された白色の左円偏光２０３は、導光手段２２の裏面に配置された

反射手段２１で反射され、左円偏光２０７になり、コレステリック層１８Ａを透過する。コレステリック層１８Ａを透過した白色の右円偏光はコレステリック層１７Ｂ，１７Ｃに入射し、赤色の右円偏光２０５のみが透過し、残りの右円偏光２１１は反射される。透過した右円偏光２０５は、位相差板１６により緑色の直線偏光２１３と同一方向の赤色直線偏光２１４に変換される。

【００１８】

反射された青色，赤色の右円偏光２０６は反射手段２１で反射され青色，赤色の左円偏光２０７になり、コレステリック層１８Ａで左円偏光２０８のまま反射され、再び反射手段２１で反射され右円偏光２０９になる。右円偏光２０９は、コレステリック層１８Ａを透過し、コレステリック層１７Ａ，１７Ｂへ入射し、青色右円偏光２１０のみ透過し、残りは反射される。透過した青色右円偏光210は、位相差板１６で直線偏光２１３，２１４と同一方向の直線偏光２１５に変換される。ここで、導光手段２２，反射手段２１に散乱による偏光解消がない場合を例に挙げて説明したが、偏光解消がある場合には、所望の偏光成分のみ透過し、不要の偏光成分は反射されることを繰り返すことにより光の再利用が行われる。

【００１９】

また、反射型色選択層であるコレステリック層からの反射光２１１，２１２は、上記と同様な現象で再利用される。

【００２０】

次に、反射型色選択手段３０，反射型偏光選択手段３１の作用について図３を用いて説明する。反射型色選択手段３０の一例として、各色の直交する一方の直線偏光を透過し、他方の直線偏光を反射する誘電体多層膜１９Ａ～１９Ｃを利用する。反射型偏光選択手段３１として例えば、少なくても３原色に対して直交する一方の直線偏光を透過し、他方の直線偏光を反射する誘電体多層膜１８Ｂとする。誘電体多層膜１９Ａ～１９Ｃと誘電体多層膜１８Ｂの偏光方向は直交するように配置する。反射型色選択手段３０としての誘電体多層膜層１９Ａ～１９Ｃ及び反射型偏光選択手段３１としての誘電体多層膜層１８Ｂを導光手段２２と反射手段２１からなる照明装置上に配置する。好ましくは、各波長に対して１／４波

長として働く位相差板１６Ａを誘電体多層膜１８Ｂと反射手段２１間に配置する。更に好ましくは、反射型色選択手段である層に合わせてストライプ状にして各色に対して位相差を合わせた位相差板１６Ａとする。

【００２１】

この反射型偏光選択手段３１としての誘電体多層膜１８Ｂを用いることは既知であり、ＷＯ９５／２７９１９に開示された技術を適用することができる。また、反射型色選択手段３０としての誘電体多層膜層１９Ａ～１９Ｃは、反射型偏光選択手段３１と同様の材料を用いることができ、赤，緑，青の直交する直線偏光の一方の直線偏光を透過し、他方の直線偏光を反射するようにそれぞれの層を設定する。

【００２２】

説明の都合上、図面に垂直方向の直線偏光を＋として、図面の左右方向の直線偏光を－として表記する。透明アクリル樹脂からなる導光手段２２からの白色無偏光である出射光２００Ａは、反射型偏光選択手段である誘電体多層膜１８Ｂに入射し、透過光は白色の＋直線偏光２０１Ａに反射光は白色の－直線偏光203Aとなる。透過光である白色の＋直線偏光２０１Ａは、誘電体多層膜層１９Ａ，１９Ｃに入射し、緑色の＋直線偏光２０２Ａが透過し、青色，赤色の＋直線偏光209Aは反射される。

【００２３】

一方、反射された白色の直線偏光２０３Ａは、位相差板１６Ａで右円偏光204Aに変換され、導光手段２２の裏面に配置された反射手段２１で反射され、左円偏光２０５Ａになり、再び位相差板１６Ａを透過して、＋直線偏光２０６Ａに変換され、誘電体多層膜層１８Ｂを透過し、＋直線偏光２０７Ａになる。誘電体多層膜層１８Ｂを透過した＋直線偏光２０７Ａは誘電体多層膜層１９Ｂ，１９Ｃに入射し、赤色の＋直線偏光２０８Ａのみが透過し、残りの＋直線偏光２１８Ａは反射され、同様な原理で再利用される。

【００２４】

反射された青色，赤色の＋直線偏光２０９Ａは、位相差板１６Ａで左円偏光２１０Ａに変換され、反射手段２１で反射され青色，赤色の右円偏光２１１Ａに

なり、再び位相差板１６Ａに入射し、－直線偏光２１２Ａになり、誘電体多層膜層１８Ｂで反射され反射された－直線偏光２１３Ａは、位相差板１６Ａを透過後右円偏光２１４Ａになり、反射手段２１で反射され左円偏光２１５Ａになり、再び位相差板１６Ａを透過し＋直線偏光２１６Ａとなり、誘電体多層膜層１８Ｂを透過する。透過光である＋直線偏光２１６Ａは、誘電体多層膜層１９Ａ，１９Ｂに入射し、青色の＋直線偏光のみが透過し、残りが反射され反射光２１９Ａとなり同様な原理で再利用される。ここで、導光手段２２，反射手段２１に散乱による偏光解消がない場合を例に挙げて説明したが、偏光解消がある場合には、所望の偏光成分のみ透過し、不要の偏光成分は反射されることを繰り返すことにより光の再利用が行われる。

【００２５】

以上図２，図３で反射型色選択手段３０と反射型偏光選択手段３１の作用について述べたが、手段３０にコレステリック層、手段３１に誘電体多層膜層を、手段３０に誘電体多層膜層、手段３１にコレステリック層を用いることもでき、限定されるものではない。

【００２６】

更には、図２，図３で説明した反射型偏光選択手段３１の視野角特性は一般的に吸収型偏光板と比較すると悪い（斜め入射により所望の偏光状態からずれた偏光状態になる）ので、照明装置の平行度に合わせて必要であれば、液晶表示素子の入射面側に図１３に示すよう吸収型偏光選択手段１５を配置することが好ましい。更に、反射型色選択手段３０の視野角特性も一般に悪く、斜め入射により偏光状態が所望の偏光状態からずれるため、照明装置の平行度に合わせて必要であれば、図２５の液晶表示素子内に吸収型色選択手段としてカラーフィルタを配置することが好ましい。

【００２７】

更には、反射型色選択手段をストライプ状に配置しそのストライプ方向に直交する方向に指向性を有する照明装置を用い、表示面側でその指向性を有する方向のみ拡散させることで反射型色選択手段間の混色のない広視野角な表示を得る。このように反射型色選択手段をストライプ状に配置すれば、そのストライプ方向

には指向性を設けることなく画素（ドット）間の混色による画質の劣化を排除することができる。また、照明装置も一方向にのみ平行度（指向性）を高めることにより、照明装置自体の出射光量を増加させることができるばかりか、構造も単純化することができる。例えば、上記照明装置のストライプ微細溝を反射型色選択手段のストライプ方向と略平行にし、導光体上部のレンズシートを省くことができる。

【００２８】

更に、反射型色選択手段の液晶層側に第２の吸収型偏光選択手段を配置することで、斜め入射に対する反射型色選択手段の特性変化（色変化，偏光変化）を補償し、斜め入射光に対する色再現性の高い表示を得る。ストライプ方向には、光源の広がりが存在しても、ストライプ方向は同色であるために混色等の問題がなくなるばかりか、光の利用効率を劣化させることなく、指向性を高めることができ光利用効率の高いカラー液晶表示装置が実現できる。

【００２９】

更に好ましくは、反射型色選択手段のストライプ方向には視野角が広い液晶表示モードを用いることで、表示面側の拡散板で拡散されない方向での斜め入射光においても表示品質の高い表示を得る。更に好ましくは、ランプの長手方向と該色選択手段のストライプ方向が略平行に配置することで照明装置の構成が容易になる。

【００３０】

上記手段を用いることで、従来問題であった基板の厚みによる画質の劣化及び、斜め入射に対するコントラスト比、表示色等の表示性能の劣化を防止でき、吸収損失の少ない低消費電力で明るい表示装置を得ることができる。つまり、光源の全方位での平行度を高め、液晶表示素子の出射側に光拡散手段を配置することで、反射型色選択手段及び液晶層を透過する光を基板に略垂直に透過させ、表示面側で光拡散させて広視野角を実現する。このため、従来問題であった斜め入射に対する問題は解決され、視野角による画質劣化のない広視野角な表示装置を得ることができる。更には、反射型色選択手段及び反射型偏光選択手段からの反射光を効率良く利用でき光の再利用による効率向上も図れる。

【００３１】

本発明のその他の手段及び作用は実施例で明らかにする。

【００３２】

【発明の実施の形態】

まず、本発明の実施例について図１を用いて説明する。本発明は、図面の左右方向に指向性の強い（平行度の高い）照明装置２０，反射型偏光選択手段としてコレステリック層３１，反射型色選択層３０としてコレステリック層３１とは逆捩じれの２層コレステリック層１７と１／４波長板として作用する位相差板１６，液晶表示素子４０の上部側に光拡散手段として偏光を維持する光散乱層１１で構成される。光散乱層１１としては、住友化学製の光制御フィルム（商品名：ルミスティ）を使用した。住友化学製の光制御フィルムは、例えば文献、住友化学１９９１，ｐ３７～ｐ４８の“光制御機能を有する高分子膜ールミスティーー”に記載の技術である。図１において反射型色選択層３０は、特定波長の特定偏光を透過し、特定偏光のその他の波長を反射する。例えば三原色(赤，緑，青)の内の一色を透過し、他の色を反射する。また、コレステリック層３１は、少なくても可視波長領域で、一方の円偏光を透過し、他方の円偏光を反射する。このように照明装置２０上にコレステリック層３１，反射型色選択層３０，液晶表示素子４０を配置することにより、前述のように各層３０，３１からの反射光を再利用でき吸収損失の少ない光利用効率の高い液晶表示装置を実現できる。

【００３３】

本発明の照明装置２０として、エッジライト型又は直下型の照明装置を用いる。直下型は光源が照光面の内側にある方式で、エッジライト型は、光源が照光面の外側に配置され、照光面である導光板２２が透明なアクリル樹脂等からなり、その１辺もしくは２辺に円柱状の光源を配置し、その外側に反射体からなるランプカバー（反射板２４）を設けて導光体内へ導入する方式である。照明装置２０のランプ光源として、表示装置の大きさに応じた発光長を有する蛍光ランプを用いる。少なくても一軸方向に指向性を持たせるため、例えば、図１のように導光板２２の裏面に図面垂直方向には一定の微細な溝を設け、背面反射板２１として反射率の高い金属（アルミ・銀等）を配置する。光源２３からの出射光の内、導

光板２２の裏面の左傾斜部に照射された成分は、反射され指向性の強い（図面左右方向）光として上部に出射される。一方、右傾斜部に照射された成分は導光板２２中を導光することにより面内の均一性が図れる。

【００３４】

本実施例では図４の斜視図、図５の断面図に示す照明装置２０を用いた。光源２３は図面に垂直方向に長く、その回りには反射板２４が配置され光源２３からの出射光２３Ａを導光板２２に導く。光源２３は冷陰極蛍光ランプを用いたが、これに限定されるものではない。前述のように、斜め入射に対する混色を無くすために、少なくても図面左右方向には指向性を持たせることが必要である。そこで、透明アクリル樹脂からなる導光板２２の裏面は、微細な溝構造を形成し、導光板２２からの出射光の少なくても図面の左右方向に指向性を持たせた。導光板２２への入射光２３Ａは、微細溝の左傾斜部に入射した光は、傾斜角Ａ２２Ａにより反射され出射光２３Ｃとして導光板２２から出射される。一方、微細構造の右傾斜部に入射した光は、傾斜角Ｂ２２Ｂにより全反射し導光２３Ｂとして図面右方向へ伝播し、図面左傾斜部へ入射した時のみ出射光２３Ｃとなり出射する。導光体２２裏面の微細構造は、ピッチ２２Ｃを２００μｍ、傾斜角Ａ２２Ａ４０度、傾斜角Ｂ２２Ｂを３度とした。但し、ピッチ２２Ｃは１０μｍ～１０００μｍ程度、傾斜角Ａ２２Ａは２０度～５０度程度、傾斜角Ｂ２２Ｂは０度から２０度程度であれば限定されるものではない。照明装置２０からの出射特性は図４に定性的に示すように、図面左右方向は指向性が強く、図面垂直方向は指向性の無い出射特性となる。図２１に本実施例で用いた照明装置の出射特性を示し、図面垂直方向特性は２５Ａ、図面左右方向特性は２５Ｂであり、一軸方向に指向性の強い照明装置を実現できた。照明装置２０としては、一軸方向（反射型色選択層３０のストライプに垂直方向）に指向性の強いものであれば本実施例に限定されるものではない。

【００３５】

液晶表示素子４０として、一対の透明基板１２，１４間に液晶層１３を挟持し、出射側透明基板１２に吸収型偏光選択層１０及び光散乱層１１を配置する。ここで、液晶層１３は、９０度捩じれを有するツイストネマチック層として、屈折

率異方性Δｎｄを０．４μｍとした。また、透明基板１２，１４はコーニング７０５９ガラス基板を使用し、その厚みを０．７mmとした。光散乱層１１は、吸収型偏光選択層１０の内側に配置する場合は偏光を維持することが必要であり、前述のように住友化学製のルミスティーを使用した。また、偏光選択層１０として日東電工製の偏光板G1220DUを用いた。図１においては、液晶を一定方向にならべるために配向膜，液晶層１３に電界を印加するための電極，スイッチング素子，配線等は省略している。また、一ドットの大きさはＲＧＢ各１００μｍ×３００μｍとした。液晶層１３として、初期配向（電圧無印加時）として、ホモジニアス配向，ツイスト配向及びホメオトロピック配向を用いることができ、ホモジニアス配向・ツイスト配向は正の誘電異方性を持つ液晶，ホメオトロピック配向は負の誘電異方性を有する液晶を用いる。ツイスト配向としては、９０度ツイスト配向が代表的であるが限定されるものではない。後述するが、少なくても図１の図面に垂直方向には広視野角になるように偏光板，液晶の配向方向等の軸を決定する。

【００３６】

従来の照明装置では画像の不鮮明さ，混色の問題が生じた。そこで、反射型色選択層３０は、液晶層１３のピッチに合わせて図面に垂直方向にストライプ状（画素（ドット）に合わせてピッチ１００μｍ）の構造とした。本発明に用いた照明装置２０は、図面の左右方向に指向性の強い、つまり、平行度の高い出射光特性を有する。これにより、反射型色選択層３０のストライプに垂直方向は、平行度が高いため、反射型色選択層３０を透過した光が液晶表示素子の同一の色に対応するドットを通過し、上部の光散乱層１１により図面の左右方向に拡散されて、画像の不鮮明さ，コントラスト比の低下，色純度の低下のない広視野角な表示を得ることができた。一方、図面に垂直方向は、同一の色を表示するために、必ずしも光源の平行度が高い必要はなく、照明装置２０からの出射光を拡散させずにそのままの表示を見るように、照明装置２０からの出射光において指向性の強い方向のみには拡散し、それに垂直方向には光散乱層１１も拡散する必要がない。これにより、少なくても反射型色選択層３０のストライプに垂直方向にのみ平行度を高めれば、ガラス基板の厚みによる混色を排除することができ、広視野

角な表示が可能となった。その白表示時の出射特性を、図２３に示す。図面垂直方向は、光散乱層１１で散乱されない方向であり、照明装置２０の出射特性を反映した図面垂直方向特性２５Ｅを得た。また、図面左右方向は、入射光が液晶層１３を透過後に光散乱層１１で散乱され２５Ｆの特性を得た。本実施例では、画像の混色が無く、コントラスト比も高い特性を得ることができた。

【００３７】

以上のように本実施例では、画像が不鮮明になることなく、広視野角名表示が実現できた。また、従来の偏光板，カラーフィルタによる吸収損失を低減でき光利用効率が大幅に向上した。まず、導光体２２からの出射光は無偏光であるが、コレステリック層３１で一方の円偏光が透過し、他方の円偏光が反射される。透過した円偏光は反射型色選択層３０で色選択を受け所望の色の円偏光のみ透過（異なる色は反射）し位相差板１６で直線偏光になり、液晶層１３で偏光変調を受け吸収型偏光選択層１０で選択され画像信号に合わせた表示がされる。一方、コレステリック層３１で反射された他方の円偏光は、導光体裏面の反射板２１で反射され逆回りの円偏光となりコレステリック層３１を透過し同様に表示に利用される。同様に、反射された異なる色の反射光は、導光体裏面の反射板２１で反射を繰り返すうちに所望の色選択層に入射した時に再利用される。従って、反射板２１や選択層３０，３１に若干の吸収損失があるが原理的にはすべての光が再利用され光利用効率が大幅に向上できた。本実施例では、コレステリック層３１及び色選択層３０が無い時と比較して光利用効率が約３．5 倍に向上した。

【００３８】

次に、一軸及び全方位における平行度の高い照明装置の実施例について説明する。

【００３９】

照明装置２０Ａの実施例として図６に示す照明装置２０上にストライプ状の三角断面形状を有するレンズシート２６を用いて、図面奥行き方向にも指向性を有する特性とした。本実施例では、頂角２６Ａを９０度、ピッチを５０μｍとしたが、限定されるものではない。その結果、左右方向出射特性３００Ａ，垂直方向出射特性３０１Ａに示すように全方位で指向性を強めることができ平行度を向上

できた。その時の出射特性を図２２に示すが、左右方向出射特性２５Ｄはやや広がったが、垂直方向出射特性２５Ｃの指向性を高めることができた。この照明装置２０Ａを図１に適用することで、指向性による正面輝度の向上と共に、反射型色選択層のストライプ方向の斜め入射光を低減でき視野角における色再現性が向上した。また、この時光散乱層１１として、住友化学製のルミスティーの光拡散軸方向を直交するように配置することで、液晶層１３の透過光を全方位にわたり広げることができ、視野角特性が向上できた。その時の白表示時の視野角特性を図２４に示す。図面垂直方向，図面左右方向共に、光散乱層１１で散乱され、図面垂直方向２５Ｇ，図面左右方向２５Ｈの視野角特性を得た。本実施例では、画像の混色が無い、コントラスト比の高い特性を得ることができた。また、図２３で得られた特性と比較して正面輝度が１．３ 倍に向上し、全方位略同等の視野角特性を得ることができた。

【００４０】

レンズシート２６に代わり、図７に示すコリメートシート２７Ａを適用する照明装置２０Ｂの実施例を図８に示す。コリメートシート２７Ａとしては、ストライプ状の配置で底面が狭くなった透明アクリル樹脂からなり、ピッチ４㎜，高さ４㎜，底面１㎜の形状を用いた。底面が狭く上面に近づくにしたがい広がる構造であれば、形状は限定されるものではない。この結果、このコリメートシート２７Ａの底面に入射した光は、図面左右方向にのみ指向性を向上した３００Ｂのような特性になり、図面奥行き方向は３０１Ｂに示す入射光視野角特性を反映した広がりのある特性となる。このコリメートシート２７Ａのストライプ方向を照明装置２０の溝方向と直交するように配置して、導光板２２とコリメートシート２７Ａ間は屈折率の略等しい透明媒体で接合した。この結果、導光体２２の裏面の微細傾斜溝部で反射された光のみ出射されるが、それ以外のコリメートシート２７Ａが無いときには導光板２２内で全反射され導光した光もコリメートシート２７Ａの底面に入射した光は出射される。従って、左右方向の出射特性３００Ｃは、導光体２２裏面の微細溝により平行光化され、垂直方向出射特性３０１Ｃは、コリメートシート２７Ａにより平行光化される。好ましくは、コリメートシート２７Ａの接着部を底面全域では無く、導光板２２裏面の微細溝に平行に一定間

隔で接着する。この照明装置２０Ｂを図１に適用すると、指向性による正面輝度の向上と共に、反射型色選択層３０のストライプ方向の斜め入射光を低減でき視野角における色再現性が向上した。

【００４１】

照明装置の全方位における出射特性を平行化するために、図９に示すコリメートシート２７Ｂを用いる。コリメートシート２７Ｂは、コリメートシート２７Ａがストライプ状の配置であったものを、正方形の底面上面とし、底面が狭くなった透明アクリル樹脂からなり、ピッチ４mm，高さ４mm，底面１mm角の形状を用いた。底面が狭く上面に近づくに従い広がる構造であれば、形状は限定されるものではない。

【００４２】

このコリメートシート２７Ｂを適用した照明装置２０Ｃ及び２０Ｄをそれぞれ図１０，図１１に示す。図１０は、コリメートシート２７Ｂを適用したサイドライト方式の照明装置２０Ｃで、導光板２２とコリメートシート２７Ｂ間は屈折率の略等しい透明媒体で接合する。その結果、導光板２２内を全反射する光の内コリメートシート２７Ｂの底面に入射した光のみ出射され、左右方向３００Ｅ，垂直方向３０１Ｅそれぞれ指向性を有する出射特性となる。また、図１１は、コリメートシート２７Ｂを適用した直下型照明装置２０Ｄで、コリメートシート27Ａの底面部以外の部分を反射体とする。これにより、一軸方向のみならず全方位において平行度を高めることができた。

【００４３】

次に、液晶表示素子４０の異なる実施例について説明する。

【００４４】

液晶表示素子４０の実施例を図１２に示す。照明装置２０として図１と同等の構造を用いたが、照明装置２０Ａ，２０Ｂ，２０Ｃ，２０Ｄいずれも使用できる。図１の実施例と異なる点は、反射型色選択層３０，反射型偏光選択層３１を透明基板１４の内側に配置した。ここで、反射型色選択層３０を内部に配置することが重要で、反射型偏光選択層３１は、画素（ドット）合わせが必要無いため透明基板１４の照明装置側に配置しても良い。図１においては、透明基板１２，

１４の厚みが画像を不鮮明にする要因である。つまり照明装置からの出射光の平行度が悪いと反射型色選択層３０と液晶層１３のドットが異なる領域を透過することになり混色等を生じる。本構成とすることで、透明基板１４の厚みの影響は無くなり照明装置２０の平行度が少なくても鮮明な画像を得ることができる。

【００４５】

液晶表示素子４０の実施例を図１３に示す。照明装置２０として図１と同等の構造を用いたが、照明装置２０Ａ，２０Ｂ，２０Ｃ，２０Ｄいずれも使用できる。図１の実施例と異なる点は、吸収型偏光選択層１５を透明基板１４と反射型色選択層３０間に配置した。吸収型偏光選択層１５として日東電工製の偏光板G1220DU を用いた。本実施例では、反射型色選択層３０，反射型偏光選択層３１としてコレステリック層を用いており、偏光度及び偏光の視野角依存性が吸収型偏光選択層と比較して悪いのが現状である。従って、反射型偏光選択層３１，反射型色選択層３０上に吸収型偏光選択層１５を配置することで、３０，３１層からの不要な偏光を吸収型偏光選択層１５で吸収することができ、透過光の偏光特性が向上し、表示のコントラスト比が向上できる。

【００４６】

液晶表示素子４０の実施例を図１４に示す。照明装置２０として図１２と同等の構造を用いたが、照明装置２０Ａ，２０Ｂ，２０Ｃ，２０Ｄいずれも使用できる。図１２の実施例と異なる点は、吸収型偏光選択層１５を反射型色選択層３０と液晶層１３間に配置した。吸収型偏光選択層１５として日東電工製の偏光板G1220DU を用いた。本実施例では、反射型色選択層３０，反射型偏光選択層３１としてコレステリック層を用いており、偏光度及び偏光の視野角依存性が吸収型偏光選択層と比較して悪いのが現状である。従って、反射型偏光選択層３１，反射型色選択層３０上に吸収型偏光選択層１５を配置することで、３０，３１層からの不要な偏光を吸収型偏光選択層１５で吸収することができ、透過光の偏光特性が向上し、表示のコントラスト比が向上できる。更に、図１３においては、透明基板１２，１４の厚みが画像を不鮮明にする要因である。つまり照明装置からの出射光の平行度が悪いと反射型色選択層３０と液晶層１３のドットが異なる領域を透過することになり混色等を生じる。本構成とすることで、透明基板１４の

厚みの影響は無くなり照明装置２０の平行度が少なくても鮮明な画像を得ることができる。

【００４７】

液晶表示素子４０の実施例を図２５に示す。図１３の実施例と異なる点は、吸収型色選択層３２を液晶層１３の近傍に配置した点である。吸収型色選択層３２として、従来から用いられている現状のＴＦＴ－ＬＣＤ等に使用しているカラーフィルタを適用した。吸収型偏光選択層１５として日東電工製の偏光板G1220DUを用いた。本実施例では、反射型色選択層３０としてコレステリック層を用いており、色選択性及び色選択性の視野角依存性が吸収型色選択層と比較して悪いのが現状である。従って、吸収型色選択層３２を配置することで、３０層からの不要な色を吸収型色選択層３２で吸収することができ、透過光の色純度が向上し、表示色の色再現性が向上できる。

【００４８】

液晶表示素子４０の実施例を図２６に示す。図１，図１２，図１３，図１４，図２５の実施例に適用できる技術であり、反射型色選択層３０を構成するコレステリック層１７のピッチをドットピッチの２倍の２００μｍとした。コレステリック層１７の２層を互いに半ピッチずらすことにより構成され、１７Ａ，１７Ｂ，１７Ｃそれぞれ緑，赤，青の特性反射を示すコレステリック層とした。このようにコレステリック層１７のピッチを２倍にすることで製造が簡略化できた。

【００４９】

次に、光散乱層１１の実施例について説明する。

【００５０】

光拡散層１１Ａの特性の一例を図１５に示す。前記実施例では、光拡散層11Aとしては、左右方向には３０２Ａのように散乱性を有し、垂直方向には３０３Ａに示すように散乱性の無い特性を有する一軸光拡散層として住友化学製のルミスティーを使用した。本実施例においては、一軸散乱性を有する光散乱層１１Ｂとして、図１６に示すストライプ状のロッドレンズアレイ（ピッチは約５０μｍ）を使用した。その他は図１３、又は図１４と同様の構造とした。本実施例で使用した照明装置２０は、左右方向に指向性の強いものであり、液晶層１３透過後に

一軸光散乱層１１Ｂで広げることで、鮮明で広視野角な表示を実現できた。

【００５１】

次に、光拡散層１１Ｃの実施例として全方位散乱性のある図１７に示す特性を有するものを用いた。光拡散層１１Ｄとして、図１８に示すマイクロレンズアレイ（ピッチ約５０μｍ）を使用した。照明装置２０Ｂとして、図８に示した全方位において平行度の高い照明装置を用いた。その他は、図１６と同様の構造とした。その結果、照明装置２０Ｂで全方位平行度を高め、各層１３，１５，３０，３１は略垂直に透過し、上部の光拡散層１１Ｄで広げることで、鮮明で広視野角な表示を実現した。

【００５２】

更に、光拡散層として、前述の一軸光拡散層１１Ｆ，１１Ｅを図１９に示すように互いの拡散する方向を略直交させることで全方位拡散性の有する拡散板を作製できた。図１８に示す構造に適用して、鮮明で広視野角な表示を実現できた。また、図２０に示すような球形のビーズ１１Ｇ２を配置し、隙間に吸収体11G1を配置し、更にはビーズへの入射効率を高めるためにビーズ１１Ｇ２より屈折率の低い低屈折率層１１Ｇ３を形成した。その結果、全方位に光拡散性を有する光拡散層が実現できた。この光拡散層１１Ｇを図１８に適用すると鮮明で広視野角な表示を実現できた。

【００５３】

次に、液晶表示素子４０の表示モード実施例について説明する。

【００５４】

基本的に反射型色選択層による混色を無くすために反射型色選択層のストライプに直交する方向には少なくても指向性を有する照明装置を用い、液晶表示素子の上面でその指向性を有する方向にのみ拡散させる構造とした。この構造においては、ストライプ方向に平行な方向では同一の色を表示するために混色がないために、ストライプ方向に指向性が無くても良い。しかし、ストライプ方向で斜め方向から見た場合は液晶表示素子の特性そのものを見ることになる。そこで、液晶表示素子の視野角特性の広い方向を配置することが必要である。そこで、一実施例として最も一般的な上下で液晶分子１３Ｂが９０度ツイストしたＴＮ液晶を

適用し、吸収型偏光選択層１０と１５の吸収軸１０Ａ，１５Ａを直交させ、上側，下側液晶分子配向方向１３Ａ，１３Ｂをそれぞれ図２７に示すような配置とし、ノーマリホワイトモードの表示モードとした。液晶層１３への電界は、図では省略してあるが、上下の透明電極に電圧を印加することで制御した。また、斜め入射に対して階調反転がなく、コントラスト比低下の少ない広視野角方向４０Ａを図１図面の垂直方向，階調反転がありコントラスト比変化の大きい狭視野角方向４０Ｂを図１の左右方向に配置した。この結果、図１図面の左右方向は、照明装置に指向性があるための画像の混色がなく、また、上部の光散乱層１１で拡散するために広視野角な表示を実現できた。一方、図１図面の垂直方向は、照明装置の指向性もなく、上部の光散乱層１１が垂直方向には拡散性を有しないにも関わらず、広視野角な表示を実現できた。

【００５５】

次に、図２８に示す初期平行配向の液晶分子１３Ｂを横電界２６により液晶分子１３Ｂの配向を制御する横電界表示モードも適用した。吸収型偏光選択層１０，１５の吸収軸１０Ａ，１５Ａをそれぞれ直交させ、液晶分子１３Ｂの配向方向１３Ａ，１３Ｃを図のようにした構造とした。横電界表示モードにおいては、４０Ｄが若干青色方向に変化し、４０Ｃが若干黄色方向に変化するが、共に階調反転は生じない。従って、反射型色選択層３０や反射型偏光選択層３１の配置に依存するが、色の変化を極力低減できる４０Ｃ方向を広視野角方向とし、液晶分子の１３Ｂのプレチルトにより上下方向で特性の異なる４０Ｄ方向を狭視野角方向とした。図１の図面に垂直方向を４０Ｃとし、左右方向を４０Ｄとした。この結果、図１図面の左右方向は、照明装置に指向性があるための画像の混色がなく、また、上部の光散乱層１１で拡散するために広視野角な表示を実現できた。一方、図１図面の垂直方向は、照明装置の指向性もなく、上部の光散乱層１１が垂直方向には拡散性を有しないにも関わらず、広視野角な表示を実現できた。

【００５６】

次に、図２９に示す正の誘電率異方性を有するホモジニアス配向（または、負の誘電率異方性を有するホメオトロピック配向）を適用した。液晶分子１３Ｂの立ち上がる（又は立ち下がる）方向は、電界により液晶分子の配向が制御される

ために視野角特性が狭く、狭視野角方向４０Ｆとした。また、それに直交する方向４０Ｅを広視野角方向として、図１の図面に垂直方向を４０Ｅとし、左右方向を４０Ｆとした。この結果、図１図面の左右方向は、照明装置に指向性があるための画像の混色がなく、また、上部の光散乱層１１で拡散するために広視野角な表示を実現できた。一方、図１図面の垂直方向は、照明装置の指向性もなく、上部の光散乱層１１が垂直方向には拡散性を有しないにも関わらず、広視野角な表示を実現できた。

【００５７】

以上、一軸又は全方位平行度の高い照明装置、一軸又は全方位散乱性を有する散乱層、方位により視野角依存性の存在する液晶表示素子の実施例を説明したが、それぞれ組み合わせて適用することが可能である。また、本実施例は、反射型色選択層及び反射型偏光選択層の実施例としてコレステリック層を用いたが、作用で述べたように誘電体多層膜、又は同様に機能するものを使用することができる。

【００５８】

【発明の効果】

以上、本発明において、反射型の色選択手段，偏光選択手段を用いて光利用効率向上を目指した時に問題となる混色，画像の不鮮明さを無くすために色選択手段をストライプ状にし少なくてもストライプ方向に垂直方向にのみ指向性を具備し、更に好ましくは、吸収型偏光選択手段と吸収型色選択手段を用いることで視野角特性を向上でき、その指向性を有する方向のみ液晶表示素子透過後拡散させることで、広視野角で鮮明な画像を得ることができる。

【図面の簡単な説明】

【図１】

本発明のカラー液晶表示装置の一実施例を示す断面図である。

【図２】

本発明のカラー液晶表示装置の作用を示す断面図である。

【図３】

本発明のカラー液晶表示装置の作用を示す断面図である。

【図４】

本発明の照明装置の一実施例を示す斜視図である。

【図５】

本発明の照明装置の一実施例を示す断面図である。

【図６】

本発明の照明装置の一実施例を示す斜視図である。

【図７】

本発明の照明装置に適用する光学部材の斜視図である。

【図８】

本発明の照明装置の一実施例を示す斜視図である。

【図９】

本発明の照明装置に適用する光学部材の斜視図である。

【図１０】

本発明の照明装置の一実施例を示す断面図である。

【図１１】

本発明の照明装置の一実施例を示す断面図である。

【図１２】

本発明のカラー液晶表示装置の一実施例を示す断面図である。

【図１３】

本発明のカラー液晶表示装置の一実施例を示す断面図である。

【図１４】

本発明のカラー液晶表示装置の一実施例を示す断面図である。

【図１５】

本発明のカラー液晶表示装置の一実施例に適用する光学部材の斜視図である。

【図１６】

本発明のカラー液晶表示装置の一実施例を示す斜視図である。

【図１７】

本発明のカラー液晶表示装置の一実施例に適用する光学部材の斜視図である。

【図１８】
本発明のカラー液晶表示装置の一実施例を示す斜視図である。
【図１９】
本発明のカラー液晶表示装置の一実施例に適用する光学部材の斜視図である。
【図２０】
本発明のカラー液晶表示装置の一実施例に適用する光学部材の断面図である。
【図２１】
本発明のカラー液晶表示装置の一特性を示す図である。
【図２２】
本発明のカラー液晶表示装置の一特性を示す図である。
【図２３】
本発明のカラー液晶表示装置の一特性を示す図である。
【図２４】
本発明のカラー液晶表示装置の一特性を示す図である。
【図２５】
本発明のカラー液晶表示素子の一実施例を示す断面図である。
【図２６】
本発明のカラー液晶表示素子の一実施例を示す断面図である。
【図２７】
本発明のカラー液晶表示素子の一実施例を示す斜視図である。
【図２８】
本発明のカラー液晶表示素子の一実施例を示す斜視図である。
【図２９】
本発明のカラー液晶表示素子の一実施例を示す斜視図である。
【図３０】
従来のカラー液晶表示装置の一実施例を示す図である。
【図３１】
従来のカラー液晶表示装置の一実施例を示す図である。

【図３２】

本発明における光源の必要な平行度について説明するための図である。

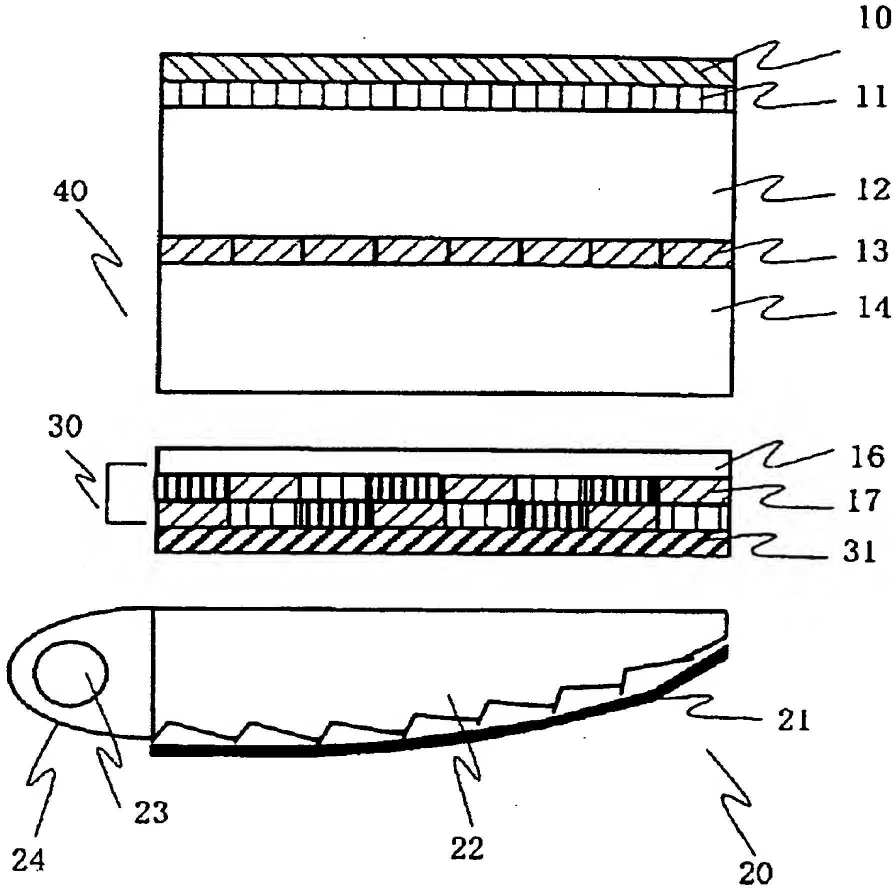
【符号の説明】

１０，１５…吸収型偏光選択層、１１…光散乱層、１２，１４…透明基板、１３…液晶層、１６…位相差板、１７，１８Ａ…コレステリック層、１８Ｂ，１９…誘電体多層膜層、２０…照明装置、２１，２４…反射板、２２…導光体、２３…光源、２５…出射特性、２６…レンズシート、３０…反射型色選択層、３１…反射型偏光選択層、４０…液晶表示素子、２００～２１９…光の偏光状態。

【書類名】　図面

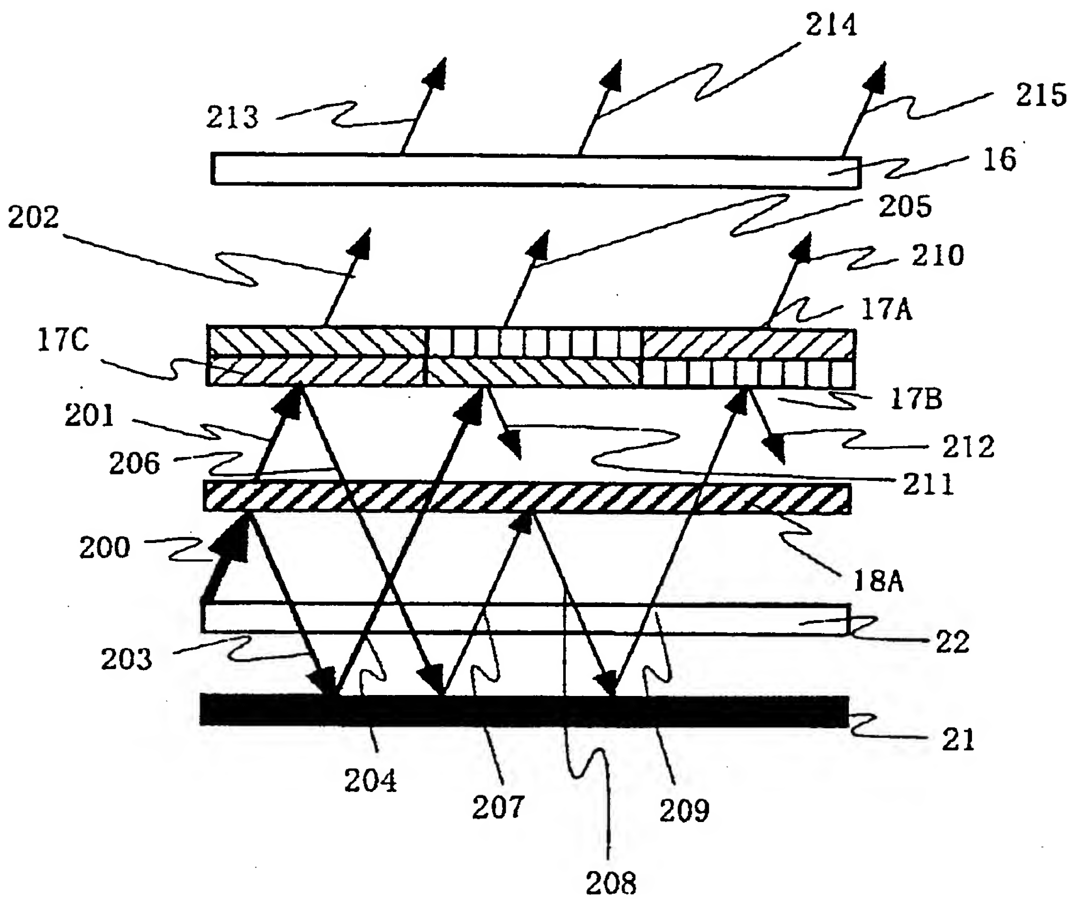
【図１】

図 1



【図２】

図 2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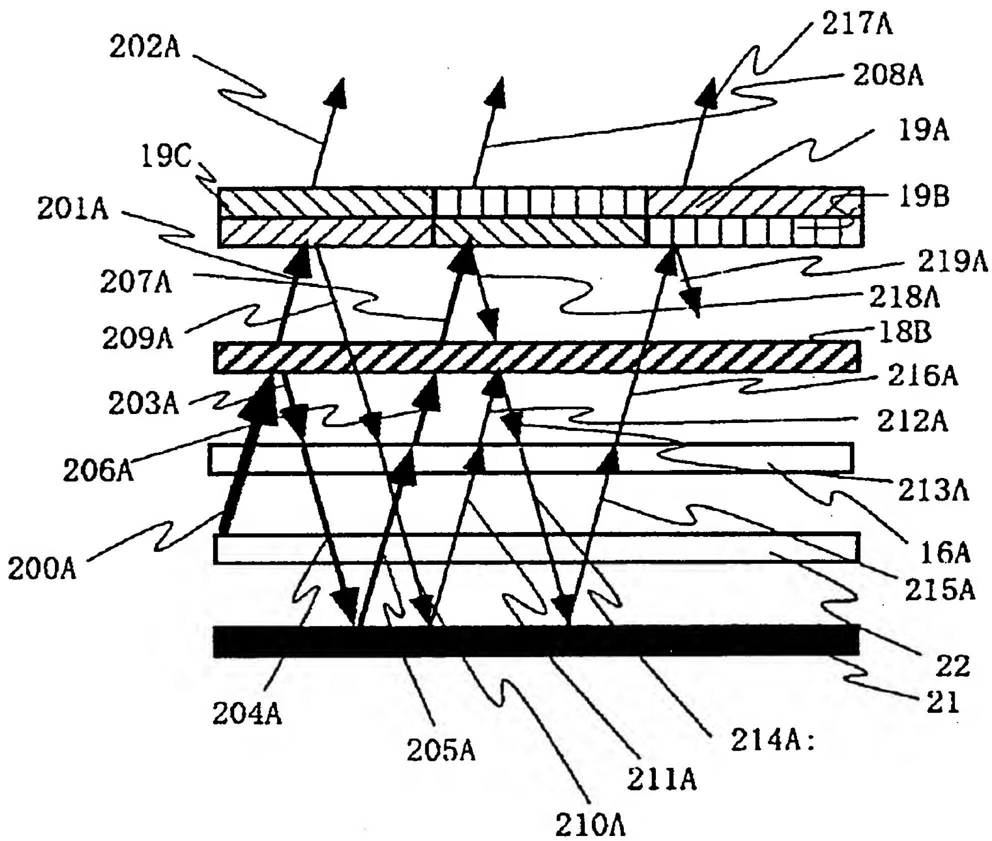
208

【図3】

図 3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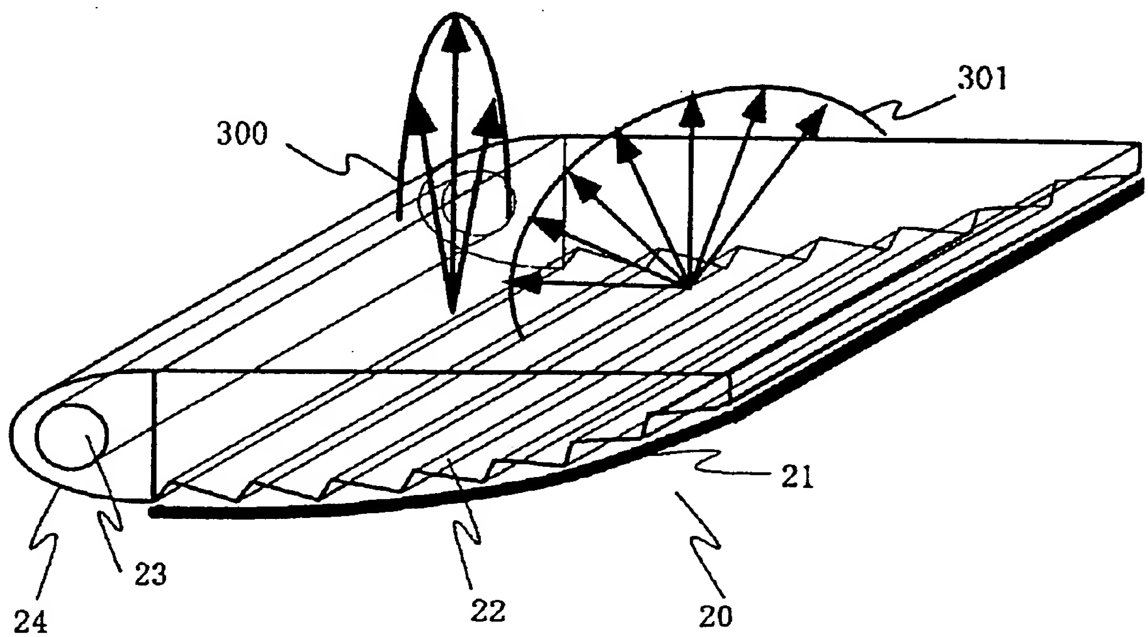
210A

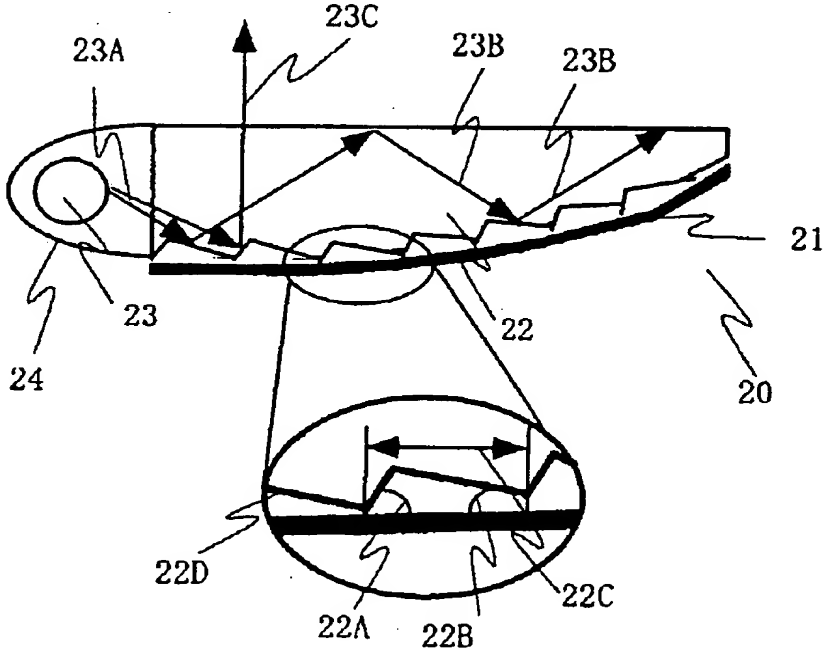
【図4】

図 4



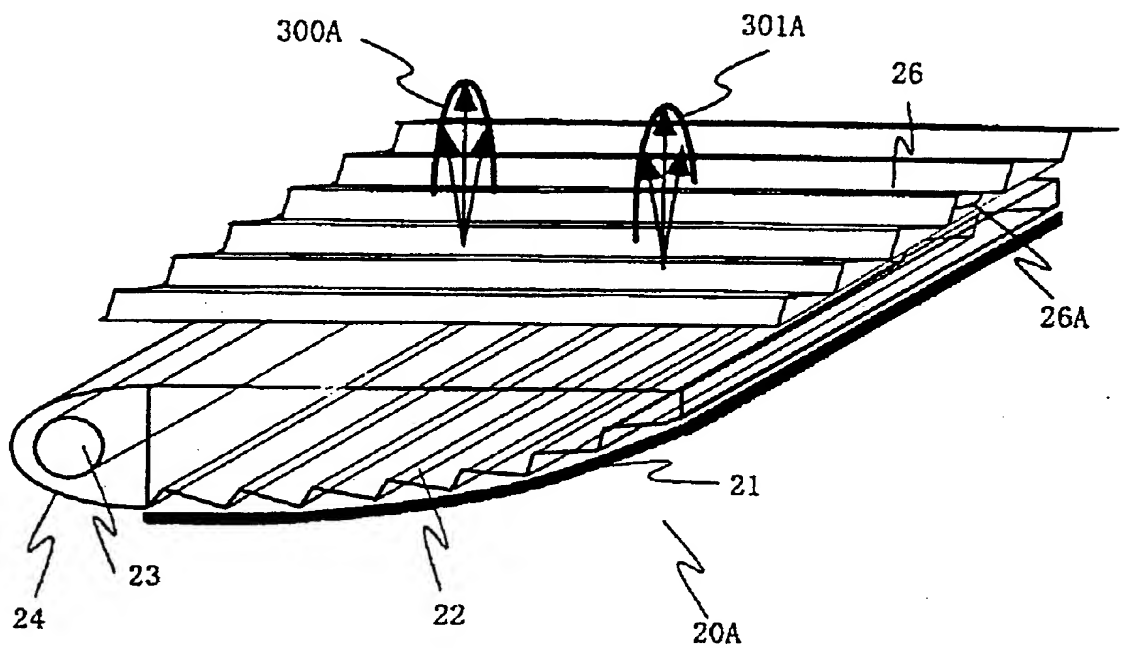
【図５】

図　5



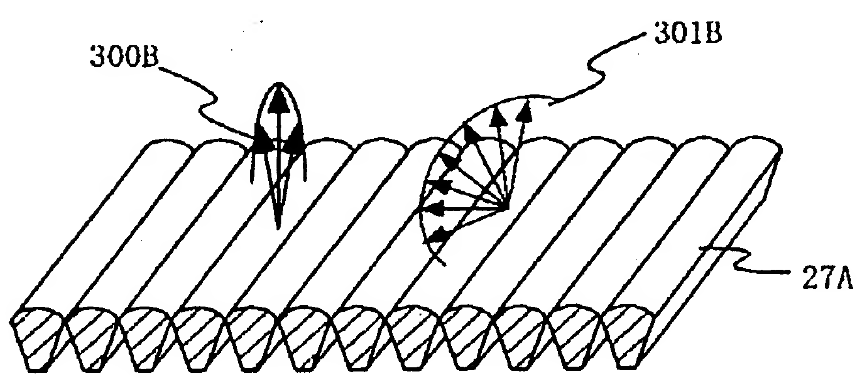
【図６】

図　6



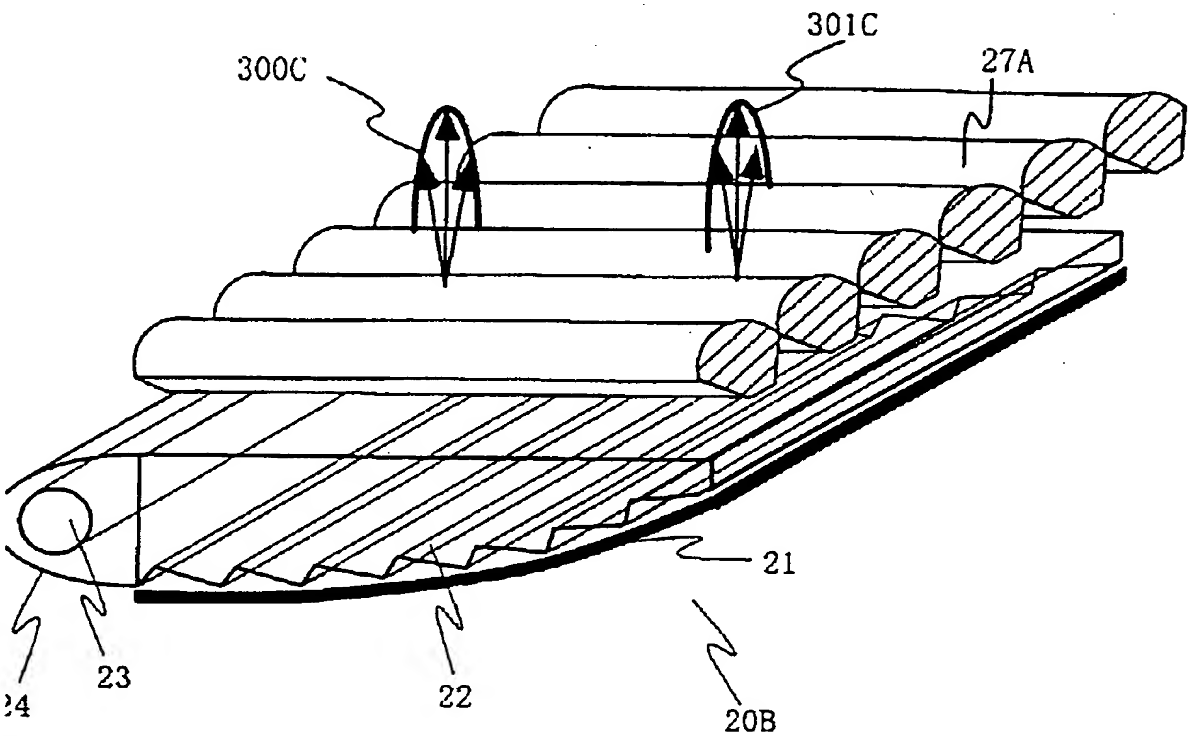
【図７】

図　7



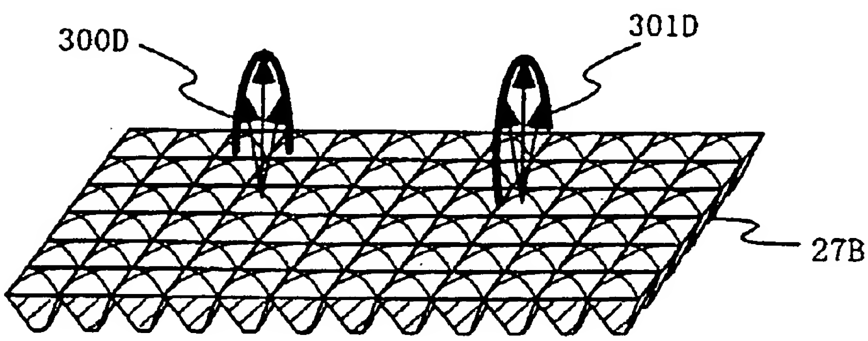
【図８】

図　8



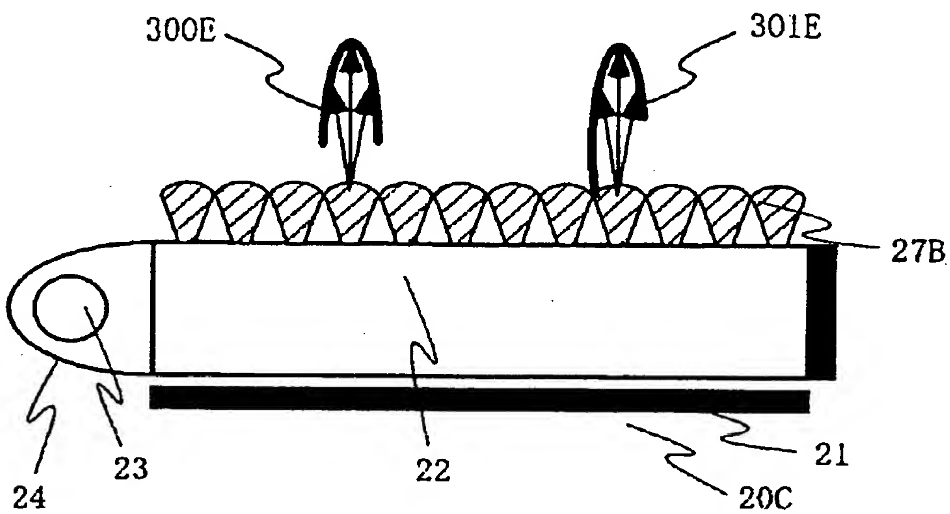
【図９】

図　9



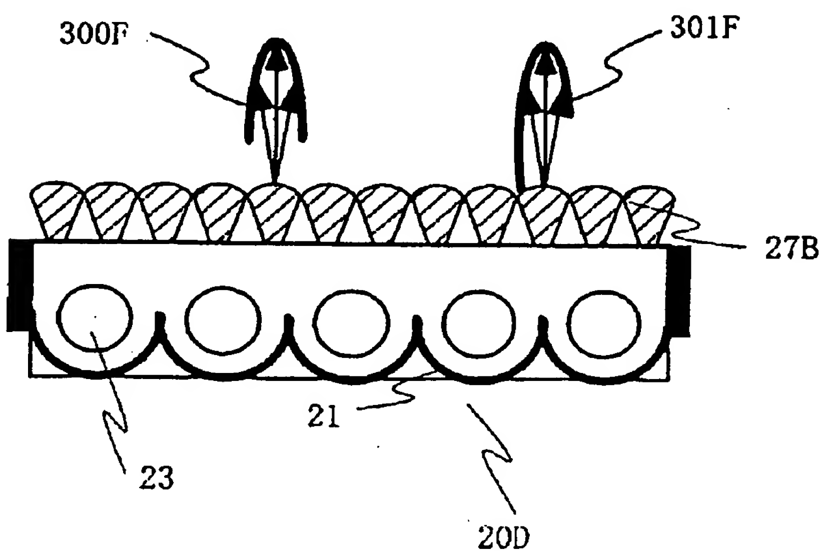
【図１０】

図　10



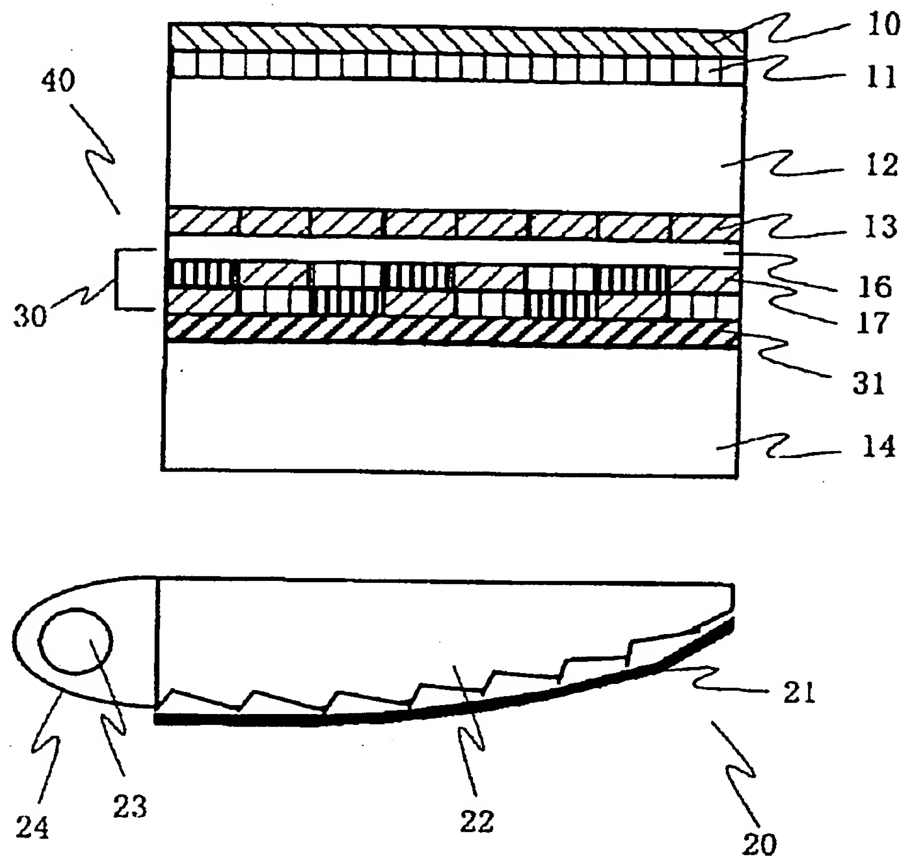
【図１１】

図　11



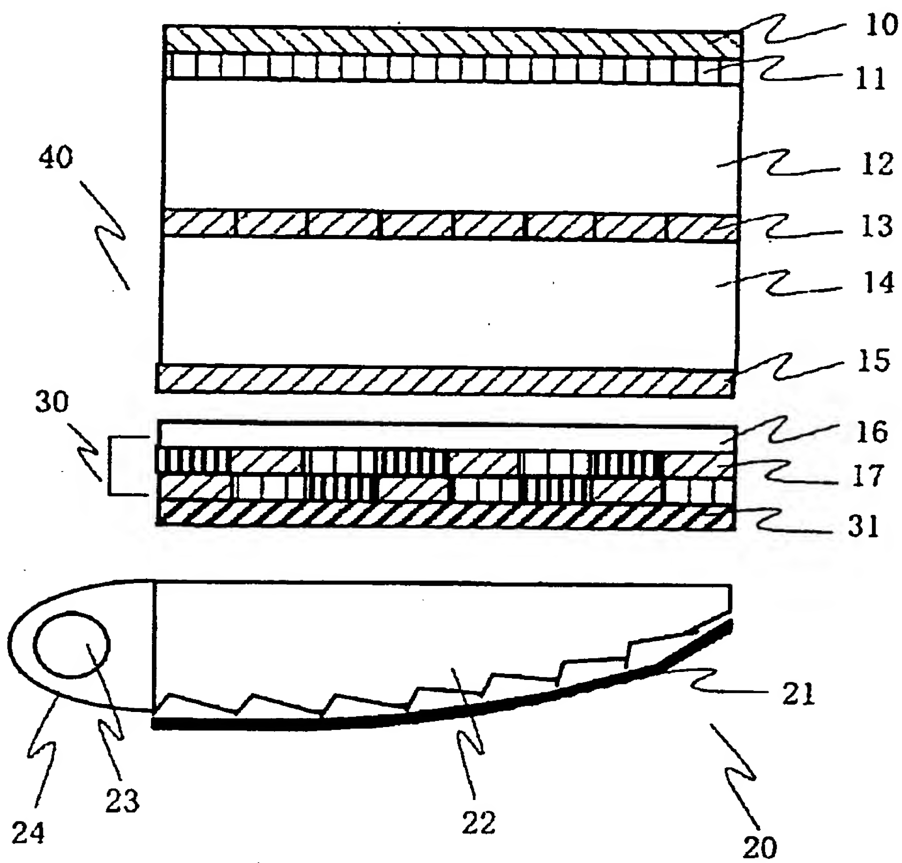
【図１２】

図 12



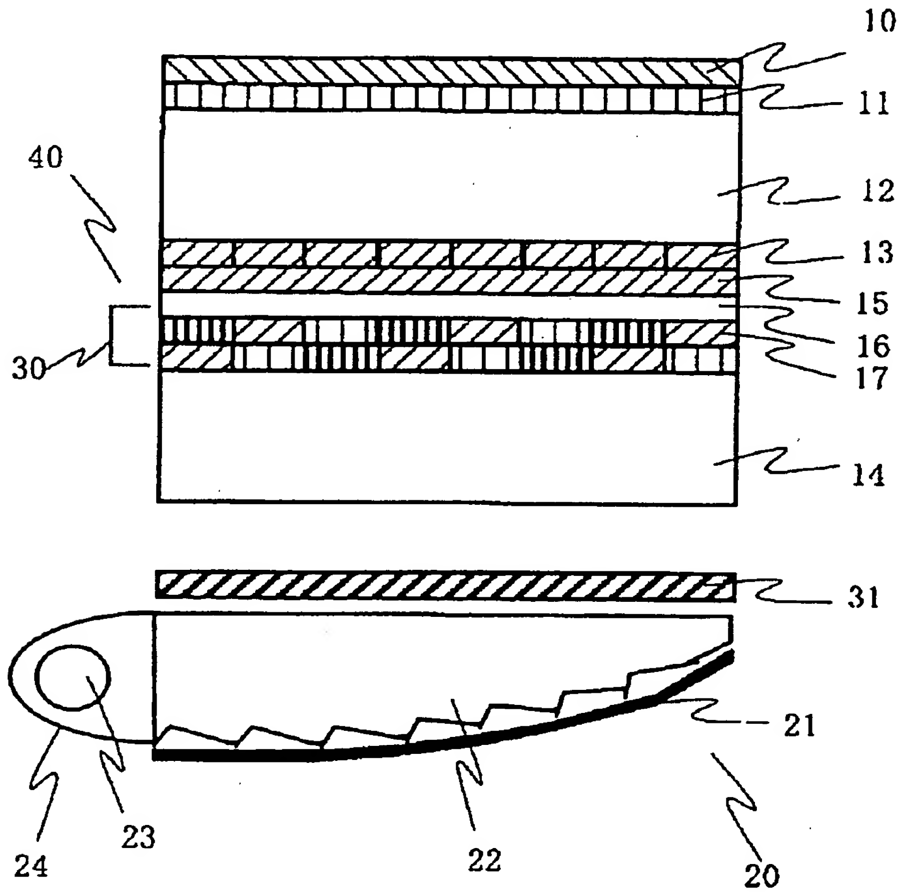
【図１３】

図 13



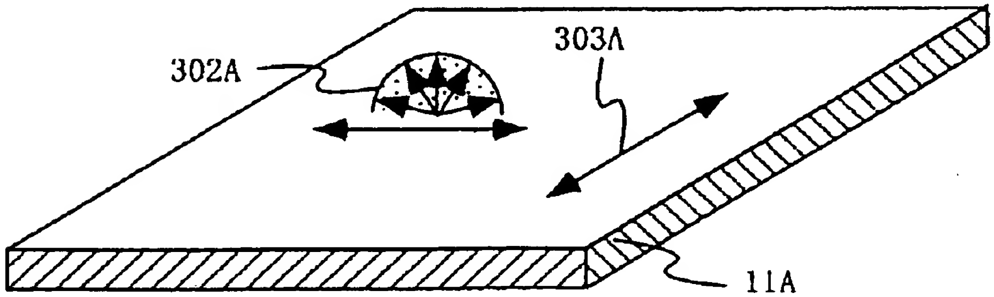
【図１４】

図 14



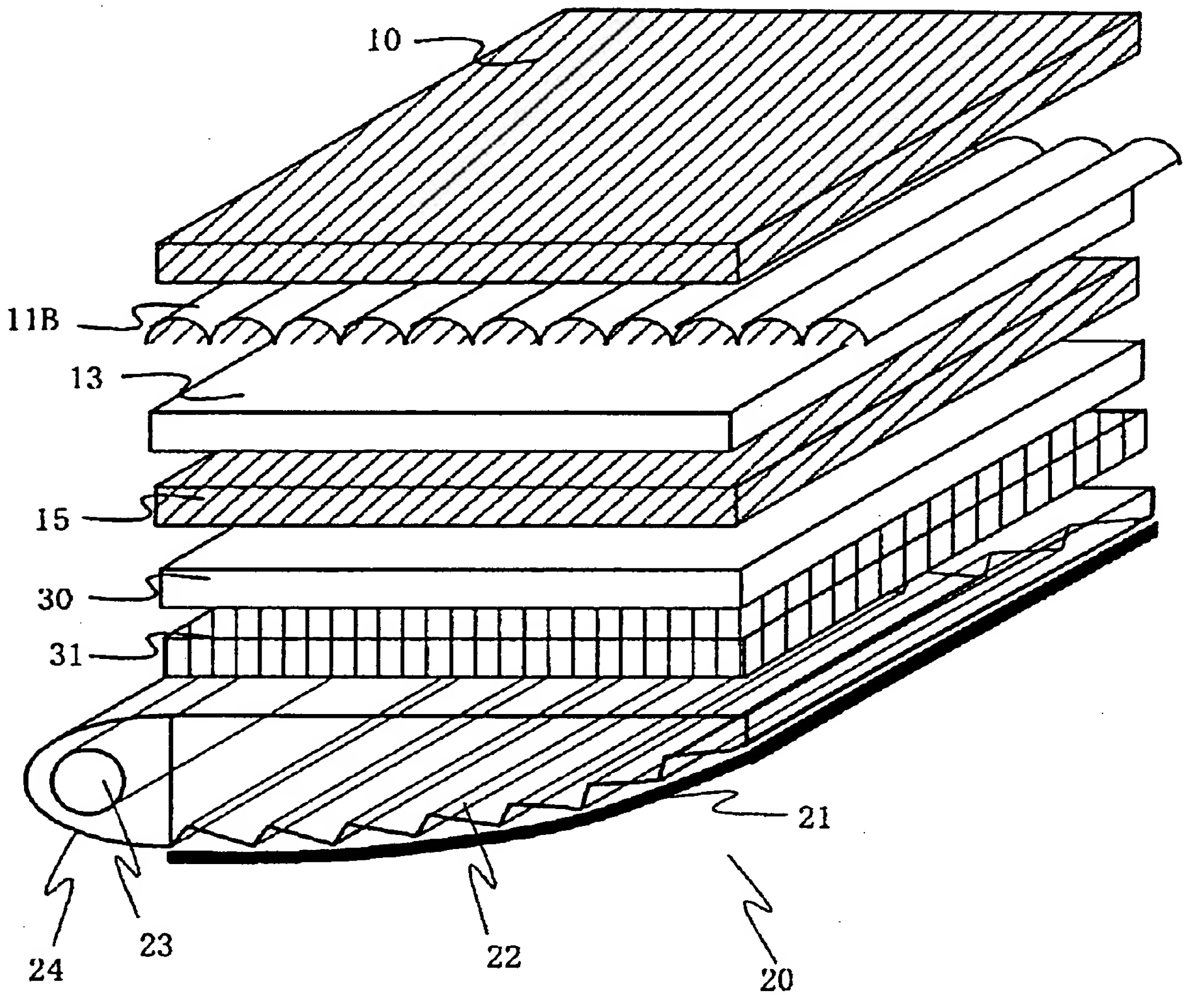
【図１５】

図 15



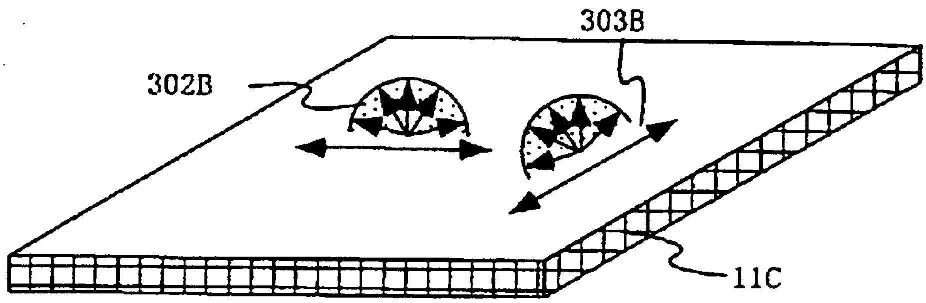
【図１６】

図　16



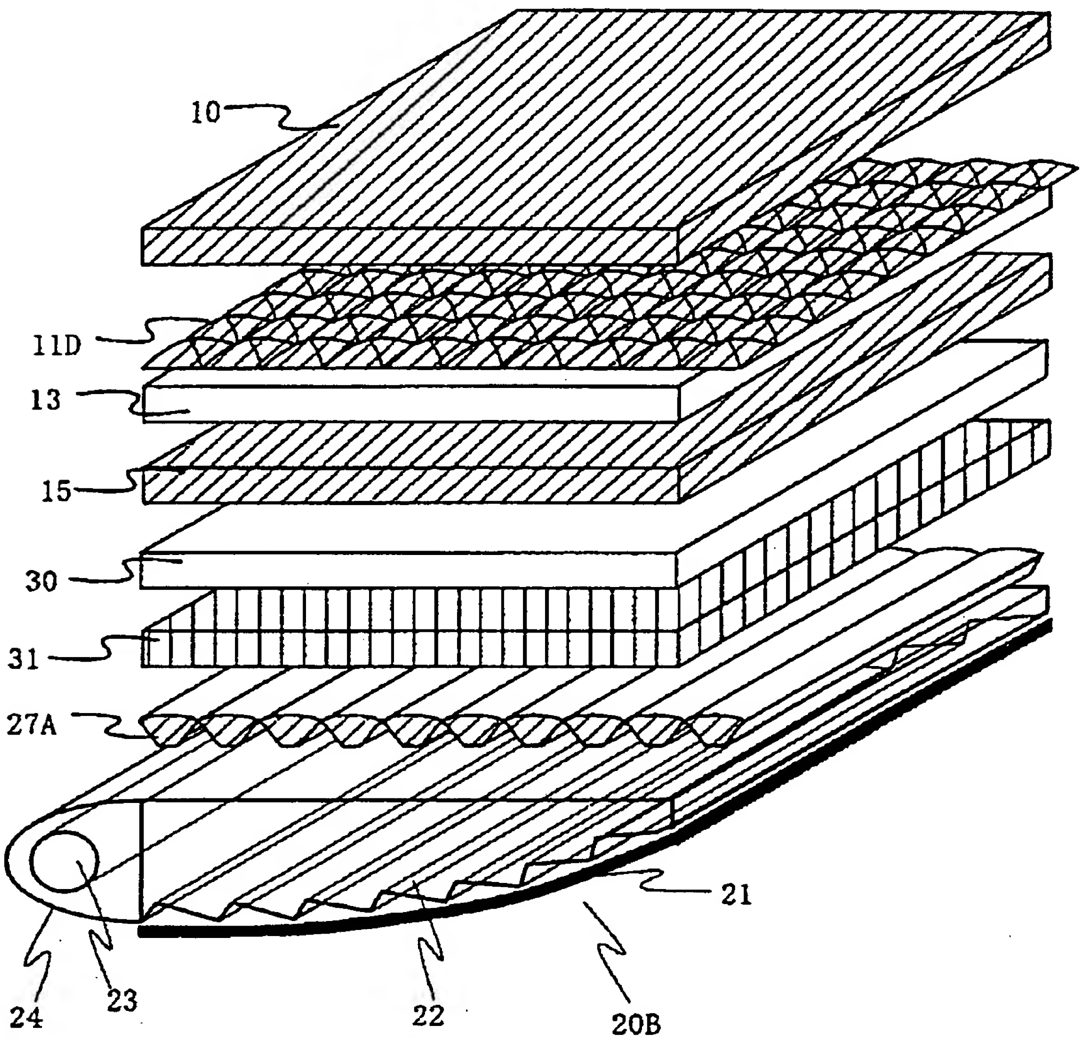
【図１７】

図 17



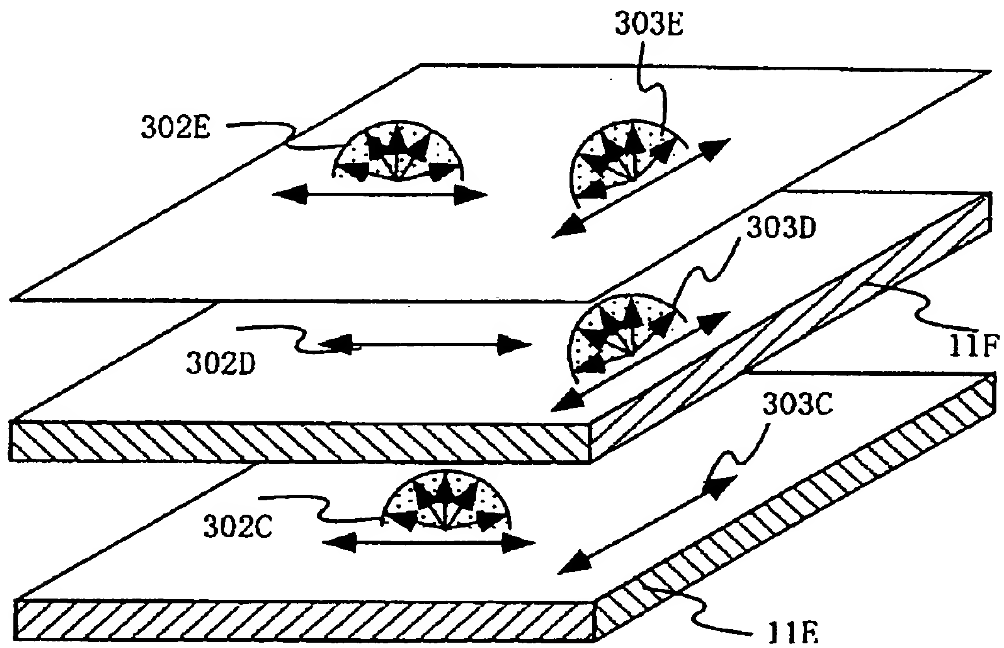
【図１８】

図　18



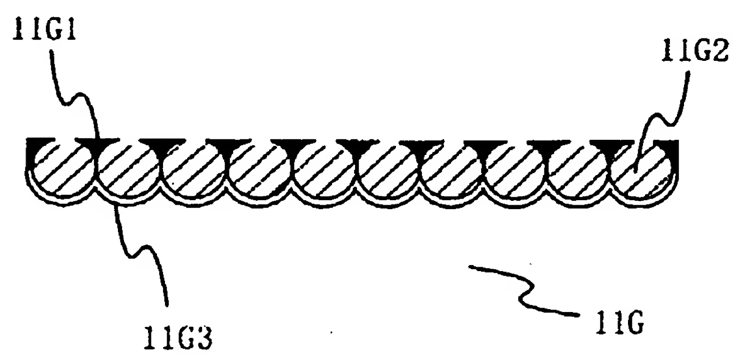
【図１９】

図　19



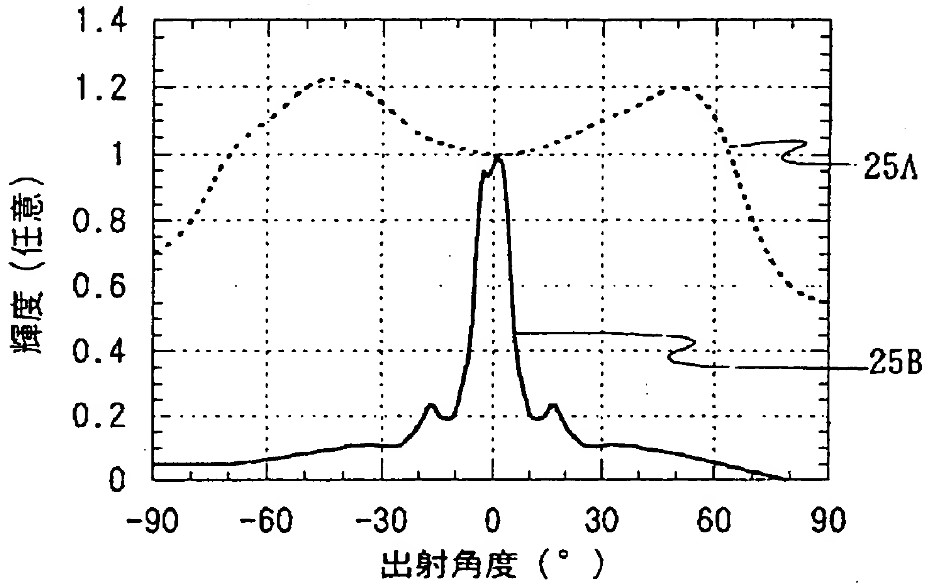
【図２０】

図　20



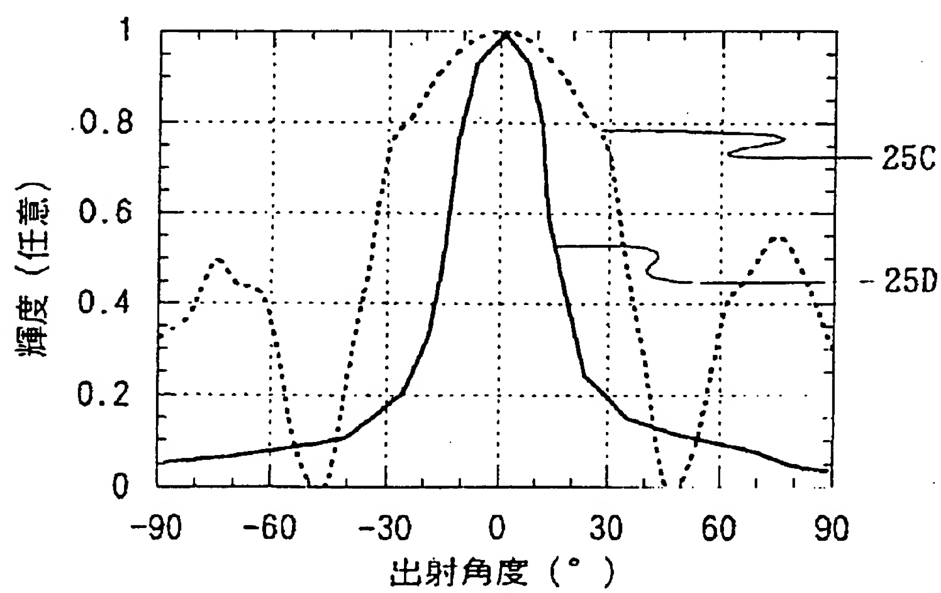
【図２１】

図　21



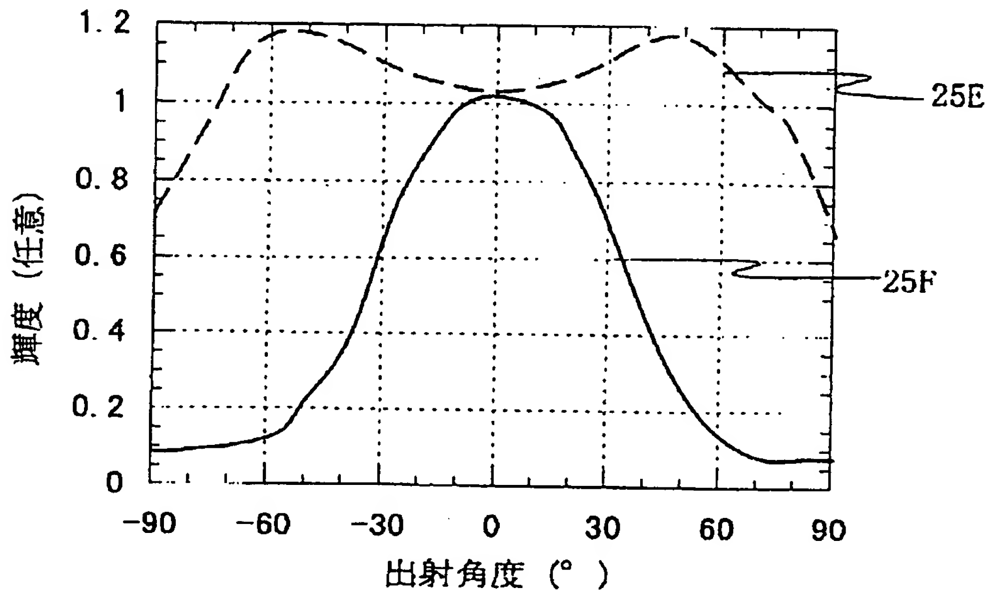
【図２２】

図　22



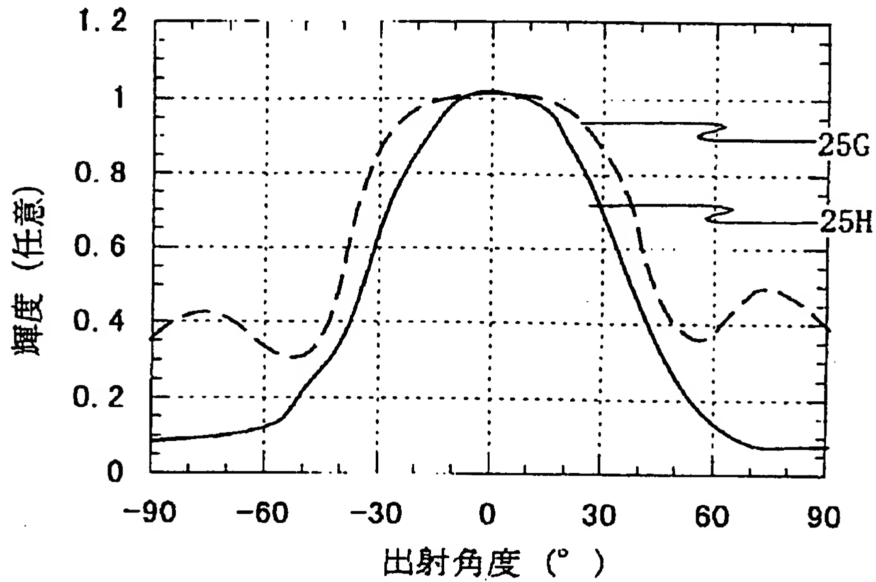
【図２３】

図　23



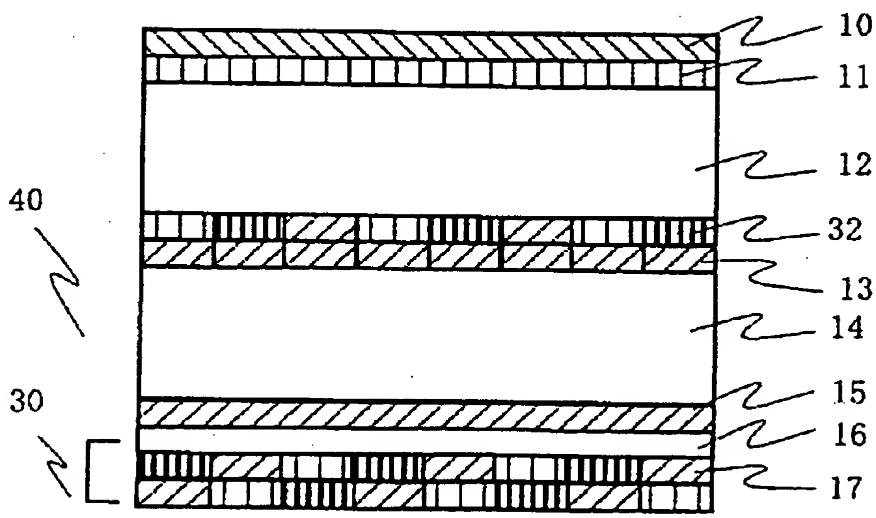
【図２４】

図 24



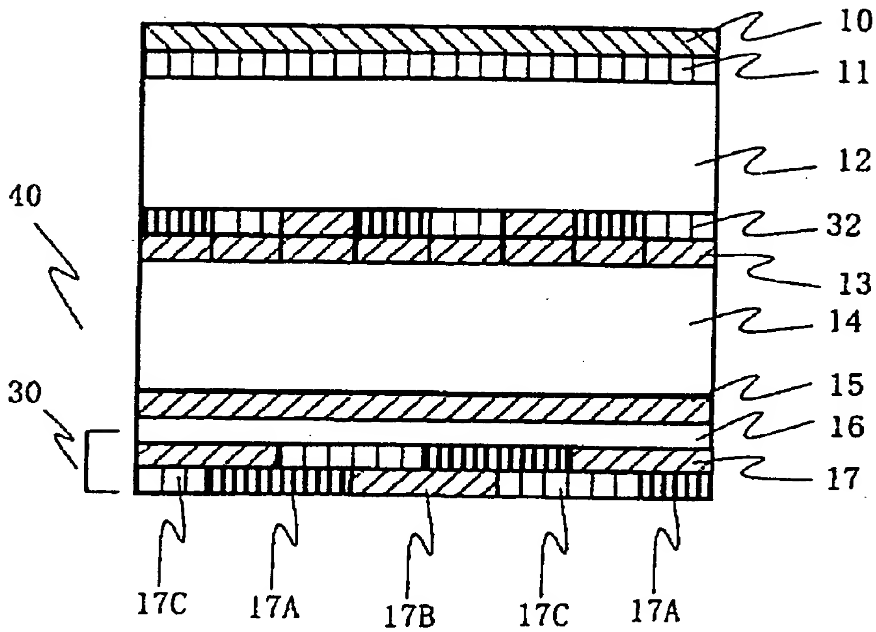
【図２５】

図 25



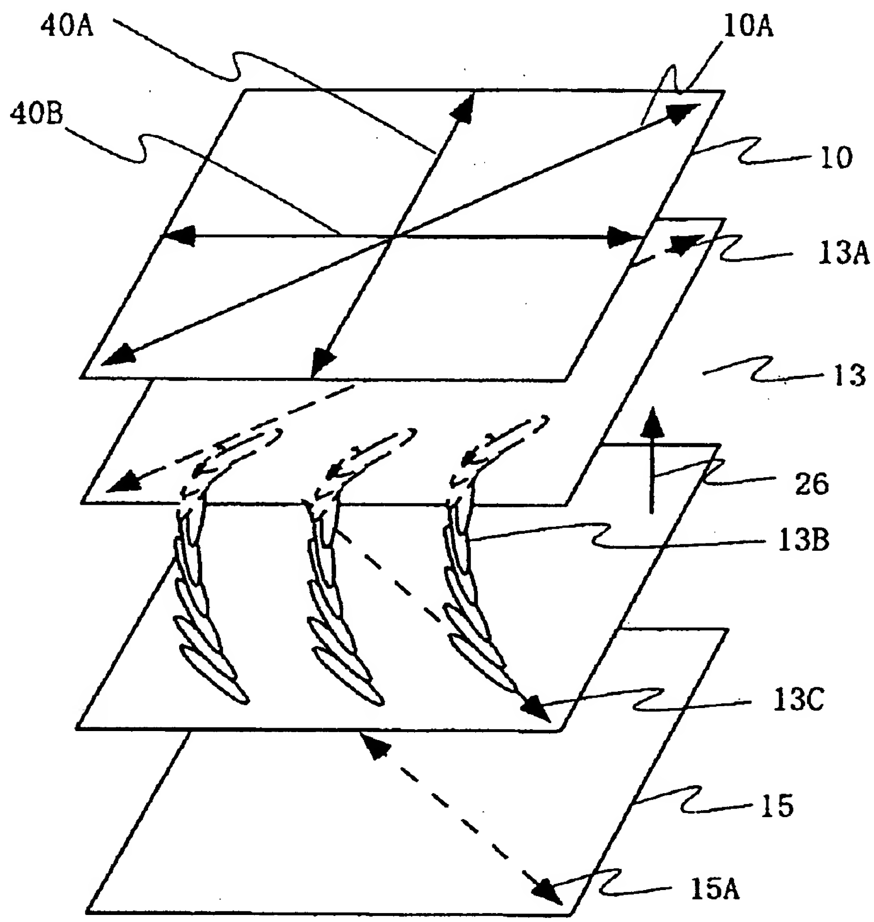
【図２６】

図　26



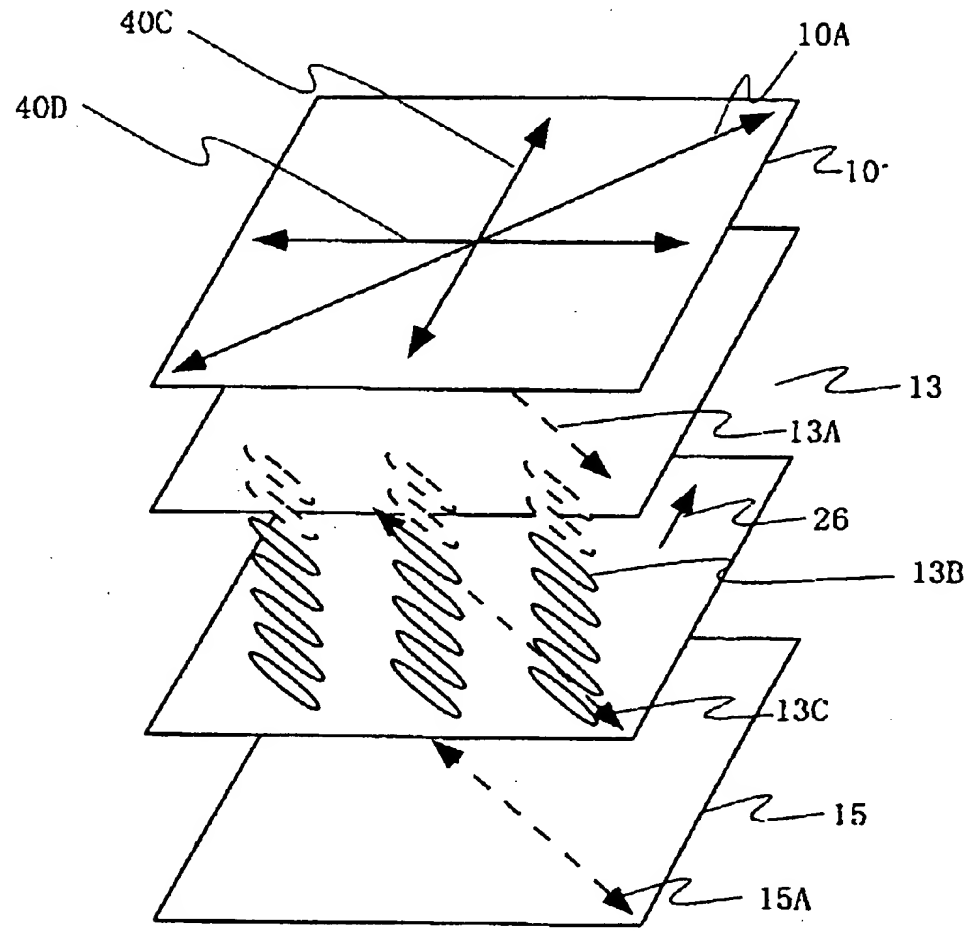
【図２７】

図　27



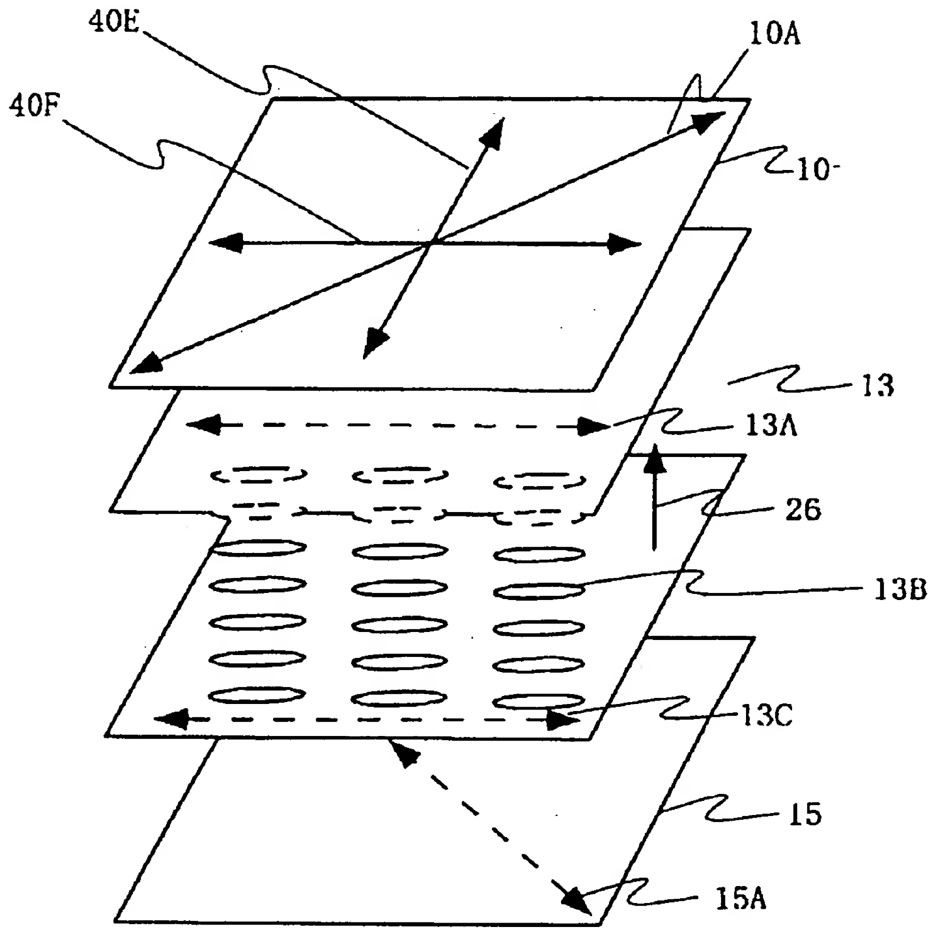
【図２８】

図 28



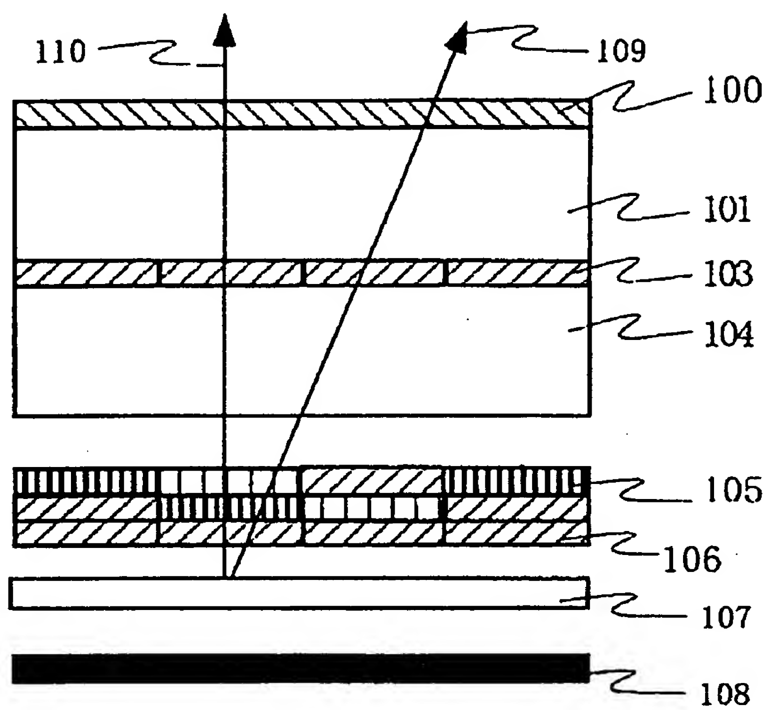
【図２９】

図　29



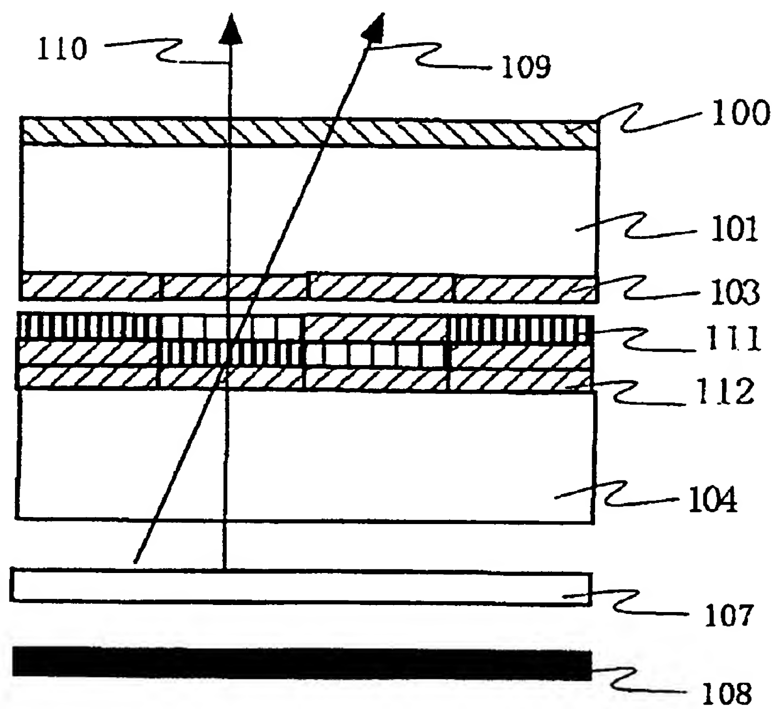
【図３０】

図　30



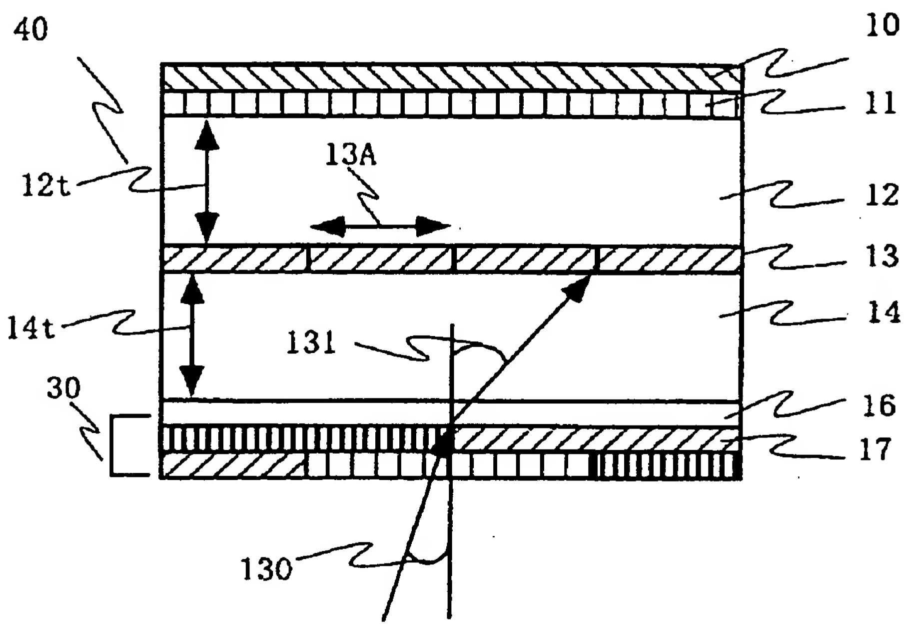
【図３１】

図　31



【図３２】

図　32



【書類名】　要約書

【要約】

【課題】

偏光板，カラーフィルタによる吸収損失を無くし光利用効率向上を目的とし、反射型色選択手段，反射型偏光選択手段を適用した時に問題となる画像の不鮮明さ，視野角依存の色変化，コントラスト比低下等の画質の低下を抑制し、広視野角で鮮明な画像を得ることにある。

【解決手段】

反射型色選択手段と反射型偏光選択手段を具備し、該色選択手段をストライプ状にし、少なくてもストライプに直交する方向には指向性を有する照明装置を用い、液晶表示素子の表示面側に少なくてもストライプに直交する方向に拡散性を有する一軸光拡散手段を配置した液晶表示装置である。更には、ストライプ方向には視野角の広い表示モードとする。

【選択図】　図１

EXHIBIT B

I, Yoshihiro Ueda, of 4-17, Sasano-cho 2-chome, Hitachinaka-shi, Ibaraki-ken 312-0018, Japan, certify that the best of my knowledge and belief, the following is a true translation made by me of the annexed document which is a copy of the specification of Japanese Patent Application Hei 10-68128 filed on March 18, 1998.

Date this 10th day of June, 2003

Yoshihiro Ueda

Yoshihiro Ueda

English translation of JP-A-10-68128 (filed on March 18, 1998)

[Title of the invention] COLOR LIQUID CRYSTAL DISPLAY DEVICE

[What is claimed is]

[Claim 1]

A liquid crystal display device comprising:

a liquid crystal display element composed of:

a liquid crystal layer interposed between a pair of transparent substrates;

an electric field applying means for controlling orientating direction of the liquid crystal layer; and

an absorption type polarized light selection means arranged on one of the pair of transparent substrates at light projecting side ; and

an illumination device arranged at rear side of the liquid crystal display element: wherein

a light diffusion means is arranged on one of the pair of transparent substrates at light projecting side ;

a reflection type color selection means and a reflective polarizing selection means are arranged on one of the pair of transparent substrates at light incident side; and

the illumination device provided with a reflecting means for reflecting reflected light from the reflection type color selection means and the reflection type polarizing means by projecting highly collimated light is arranged at the back plane of the liquid crystal display element.

[Claim 2]

A liquid crystal display device comprising:

a liquid crystal display element composed of:

a liquid crystal layer interposed between a pair of transparent substrates;

an electric field applying means for controlling orientating direction of the liquid crystal layer; and

an absorption type polarized light selection means arranged on one of the pair of transparent substrates at light projecting side ; and

an illumination device arranged at rear side of the liquid crystal display element: wherein

a light diffusion means is arranged on one of the pair of transparent substrates at light projecting side ;

a reflective polarizing selection means and a stripe shaped reflection type color selection means are arranged on one of the pair of transparent substrates at light incident side;

the illumination device provided with a reflecting means for reflecting reflected light from the reflection type color selection means and the reflection type polarizing means having a directivity at least in a direction approximately perpendicularly intercrossing with the stripe direction of the reflection type color selection means is arranged at the back plane of the liquid crystal display element;

the light diffusion means has a diffusive function at least in an uniaxial direction; and

the diffusive axis of the light diffusion means intercrosses with the orientating direction of the illumination device.

[Claim 3]

A liquid crystal display device comprising:

a liquid crystal display element composed of:

a liquid crystal layer interposed between a pair of transparent substrates;

an electric field applying means for controlling orientating direction of the liquid crystal layer; and

an absorption type polarized light selection means arranged on

one of the pair of transparent substrates at light projecting side ; and

an illumination device arranged at rear side of the liquid crystal display element: wherein

a light diffusion means is arranged on one of the pair of transparent substrates at light projecting side ;

a reflective polarizing selection means and a stripe shaped reflection type color selection means are arranged on one of the pair of transparent substrates at light incident side;

the illumination device provided with a reflecting means for reflecting reflected light from the reflection type color selection means and the reflection type polarizing means having a directivity at least in a direction approximately perpendicularly intercrossing with the stripe direction of the reflection type color selection means is arranged at the back plane of the liquid crystal display element;

the light diffusion means has a diffusive function at least in an uniaxial direction; and

the diffusive axis of the light diffusion means approximately perpendicularly intercrosses with the orientating direction of the illumination device.

[Claim 4]

A liquid crystal display device according to any one of claims 1 to 3, wherein

the half value . $_1$ (an angular range where the brightness becomes 1/2 of the peak value) of projected light from the illumination device in a direction satisfies the following equation:

[math. 1]

$. _1 . \sin^{-1} (n\sin(\tan^{-1} (2d/t)))$ ...(1)

where,

t: a thickness of each of pair of transparent substrate

n: a refractive index of each of the pair of transparent substrates

d: a length of the pixel in a minor axis direction of the pixel.

[Claim 5]

A liquid crystal display device according to any one of claims 1 to 4, wherein

a second absorption type polarized light selection means is provided on one of the pair of transparent substrates at the light incident side.

[Claim 6]

A liquid crystal display device according to any one of claims 2 to 5, wherein

the liquid crystal layer, the reflective polarizing selection means, the absorption type polarized light selection means, and the reflection type color selection means are arranged so as to make at least a viewing angle in the stripe direction of the reflection type color selection means wide.

[Claim 7]

A liquid crystal display device according to any one of claims 2 to 6, wherein

at least a waveguide of the illumination device has fine grooves at rear plane and a directivity in an axial direction.

[Claim 8]

A liquid crystal display device according to any one of claims 2 to 7 , wherein

the illumination device is a side light type, and the major axis of the lamp is approximately parallel to the stripe direction of the reflection type color selection means.

[Claim 9]

A liquid crystal display device according to any one of claims 1 to 8, wherein

the illumination device is provided with at least a light control means having a directivity in an axis direction.

[Claim 10]

A liquid crystal display device according to any one of claims 1 to 9, wherein

one of the pair of transparent substrates is provided with an absorption type color selective means.

[Claim 11]

A liquid crystal display device according to any one of claims 1 to 10, wherein

the liquid crystal layer is a twisted nematic liquid crystal layer twisted approximately 90 degrees, and

the absorption type polarized light selection means and the reflective polarizing selection means are arranged so as to form a normally-white display mode.

[Claim 12]

A liquid crystal display device according to any one of claims 1 to 10, wherein

the liquid crystal layer is controllable to be homogeneous orientation or homeotropic orientation by the electric field applying means.

[Claim 13]

A liquid crystal display device according to any one of claims 1 to 10, wherein

an electric field is supplied in parallel to the pair of transparent substrates by the electric field applying means.

[Claim 14]

A liquid crystal display device according to any one of claims 1 to 13, wherein

the light diffusion means is arranged inside of the absorption type polarized light selection means in order to maintain the polarized light.

[Claim 15]

A liquid crystal display device according to any one of claims 1 to 14, wherein

a dielectric multi-layered film for controlling transmission and reflection of polarized light is contained in at least one of the reflective polarizing selection means and the reflection type color selection means.

[Claim 16]

A liquid crystal display device according to any one of claims 1 to 14, wherein

a cholesteric liquid crystal layer for controlling transmission and reflection of polarized light is contained in at least one of the reflective polarizing selection means and the reflection type color selection means.

[Claim 17]

A liquid crystal display device comprising:

a liquid crystal display element composed of:

a liquid crystal layer interposed between a pair of transparent substrates;

an electric field applying means for controlling orientating direction of the liquid crystal layer; and

an absorption type polarized light selection means arranged on one of the pair of transparent substrates at light projecting side ; and

an illumination device arranged at rear side of the liquid crystal display element: wherein

a light diffusion means is arranged on one of the pair of

transparent substrates at light projecting side ;

a reflective polarizing selection means and a stripe shaped reflection type color selection means are arranged on one of the pair of transparent substrates at light incident side;

the illumination device provided with a reflecting means for reflecting reflected light from the reflection type color selection means and the reflection type polarizing means having a directivity at least in a direction approximately perpendicularly intercrossing with the stripe direction of the reflection type color selection means is arranged at the back plane of the liquid crystal display element;

the light diffusion means has a diffusive function at least in an uniaxial direction;

the diffusive axis of the light diffusion means approximately perpendicularly intercrosses with the orientating direction of the illumination device; and

the liquid crystal display element is arranged so that the direction of wide view angle of the liquid crystal display element coincides approximately with the stripe direction of the reflection type color selection means.

[Claim 18]

A liquid crystal display device comprising:

a liquid crystal display element composed of:

a liquid crystal layer interposed between a pair of transparent substrates;

an electric field applying means for controlling orientating direction of the liquid crystal layer; and

an absorption type polarized light selection means arranged on one of the pair of transparent substrates at light projecting side ; and

an illumination device arranged at rear side of the liquid crystal

display element: wherein

a light diffusion means is arranged on one of the pair of transparent substrates at light projecting side ;

a second absorption type polarized light selection means, a reflective polarizing selection means, and a stripe shaped reflection type color selection means are arranged on one of the pair of transparent substrates at light incident side;

the illumination device provided with a reflecting means for reflecting reflected light from the reflection type color selection means and the reflection type polarizing means having a directivity at least in a direction approximately perpendicularly intercrossing with the stripe direction of the reflection type color selection means is arranged at the back plane of the liquid crystal display element;

the light diffusion means has a diffusive function at least in an uniaxial direction;

the diffusive axis of the light diffusion means approximately perpendicularly intercrosses with the orientating direction of the illumination device; and

the liquid crystal display element is arranged so that the direction of wide view angle of the liquid crystal display element coincides approximately with the stripe direction of the reflection type color selection means.

[Claim 19]

A liquid crystal display device comprising:

a liquid crystal display element composed of:

a liquid crystal layer interposed between a pair of transparent substrates;

an electric field applying means for controlling orientating direction of the liquid crystal layer; and

an absorption type polarized light selection means arranged on one of the pair of transparent substrates at light projecting side ; and

an illumination device arranged at rear side of the liquid crystal display element: wherein

a light diffusion means is arranged on one of the pair of transparent substrates at light projecting side ;

a second absorption type polarized light selection means, a reflective polarizing selection means, and a stripe shaped reflection type color selection means are arranged on one of the pair of transparent substrates at light incident side;

an absorption type color selective means is arranged on one of the pair of transparent substrates at a position coinciding with position of the reflection type color selection means;

the illumination device provided with a reflecting means for reflecting reflected light from the reflection type color selection means and the reflection type polarizing means having a directivity at least in a direction approximately perpendicularly intercrossing with the stripe direction of the reflection type color selection means is arranged at the back plane of the liquid crystal display element;

the light diffusion means has a diffusive function at least in an uniaxial direction;

the diffusive axis of the light diffusion means approximately perpendicularly intercrosses with the orientating direction of the illumination device; and

the liquid crystal display element is arranged so that the direction of wide view angle of the liquid crystal display element coincides approximately with the stripe direction of the reflection type color selection means.

[Claim 20]

A liquid crystal display device comprising:

a liquid crystal display element composed of:

a liquid crystal layer interposed between a pair of transparent substrates;

an electric field applying means for controlling orientating direction of the liquid crystal layer; and

an absorption type polarized light selection means arranged on one of the pair of transparent substrates at light projecting side ; and

an illumination device arranged at rear side of the liquid crystal display element: wherein

a light diffusion means is arranged on one of the pair of transparent substrates at light projecting side ;

a second absorption type polarized light selection means, a reflective polarizing selection means, and a stripe shaped reflection type color selection means are arranged on one of the pair of transparent substrates at light incident side;

the illumination device provided with a reflecting means for reflecting reflected light from the reflection type color selection means and the reflection type polarizing means having a directivity at least in a direction approximately perpendicularly intercrossing with the stripe direction of the reflection type color selection means is arranged at the back plane of the liquid crystal display element;

the light diffusion means is arranged inside of the absorption type polarized light selection means to maintain the polarized light, and has a diffusive function at least in an uniaxial direction;

the diffusive axis of the light diffusion means approximately perpendicularly intercrosses with the orientating direction of the illumination device; and

the liquid crystal display element is arranged so that the

direction of wide view angle of the liquid crystal display element coincides approximately with the stripe direction of the reflection type color selection means.

[Claim 21]

A liquid crystal display device comprising:

a liquid crystal display element composed of:

a liquid crystal layer interposed between a pair of transparent substrates;

an electric field applying means for controlling orientating direction of the liquid crystal layer; and

an absorption type polarized light selection means arranged on one of the pair of transparent substrates at light projecting side ; and

an illumination device arranged at rear side of the liquid crystal display element: wherein

a light diffusion means is arranged on one of the pair of transparent substrates at light projecting side ;

a second absorption type polarized light selection means, a reflective polarizing selection means, and a stripe shaped reflection type color selection means are arranged on one of the pair of transparent substrates at light incident side;

an absorption type color selective means is arranged on one of the pair of transparent substrates at a position coinciding with position of the reflection type color selection means;

the illumination device provided with a reflecting means for reflecting reflected light from the reflection type color selection means and the reflection type polarizing means having a directivity at least in a direction approximately perpendicularly intercrossing with the stripe direction of the reflection type color selection means is arranged at the back plane of the liquid crystal display element;

the light diffusion means is arranged inside of the absorption type polarized light selection means to maintain the polarized light, and has a diffusive function at least in an uniaxial direction;

the diffusive axis of the light diffusion means approximately perpendicularly intercrosses with the orientating direction of the illumination device; and

the liquid crystal display element is arranged so that the direction of wide view angle of the liquid crystal display element coincides approximately with the stripe direction of the reflection type color selection means.

[Claim 22]

A liquid crystal display device comprising:

a liquid crystal display element composed of:

a twisted nematic liquid crystal layer twisted approximately 90 degrees interposed between a pair of transparent substrates;

an electric field applying means for controlling orientating direction of the liquid crystal layer; and

an absorption type polarized light selection means arranged on one of the pair of transparent substrates at light projecting side ; and

an illumination device arranged at rear side of the liquid crystal display element: wherein

a light diffusion means is arranged on one of the pair of transparent substrates at light projecting side ;

a second absorption type polarized light selection means, a reflective polarizing selection means, and a stripe shaped reflection type color selection means are arranged on one of the pair of transparent substrates at light incident side;

an absorption type color selective means is arranged on one of the pair of transparent substrates at a position coinciding with position of

the reflection type color selection means;

the illumination device provided with a reflecting means for reflecting reflected light from the reflection type color selection means and the reflection type polarizing means having a directivity at least in a direction approximately perpendicularly intercrossing with the stripe direction of the reflection type color selection means is arranged at the back plane of the liquid crystal display element;

the light diffusion means is arranged inside of the absorption type polarized light selection means to maintain the polarized light, and has a diffusive function at least in an uniaxial direction;

the diffusive axis of the light diffusion means approximately perpendicularly intercrosses with the orientating direction of the illumination device; and

the liquid crystal display element is arranged so that the direction of wide view angle of the liquid crystal display element coincides approximately with the stripe direction of the reflection type color selection means.

[Detailed description of the invention]

[0001]

[technical field of the invention]

The present invention relates to a color liquid crystal display device by re-utilization of light using polarized light conversion and wave length selectivity. Particularly, to a transparent type color liquid crystal display device, in which an illumination device is arranged at back plane of the color liquid crystal display element.

[0002]

[prior art]

Currently, the technical advancement in liquid crystal display devices, particularly in color liquid crystal display devices Is significant

such that display devices having almost the same image quality as a CRT have been realized. Furthermore, a back-light becomes indispensable for direct visual type color liquid crystal display device, because note type personal computers becomes popular, and the display without the back-light as an illumination device can not stand as a display.

[0003]

Currently, the direct visual type color liquid crystal display device occupying the market can be separated into two types: a liquid crystal display device driven by active matrix drive using TFT (thin film transistor) and STN (super twisted nematic) liquid crystal display device driven by multiplex drive. Both of the liquid crystal display devices display images by arranging polarized light plates at both sides of an element, which is composed of a liquid crystal layer interposed between glass plates, and converting polarized light condition of a linear polarized light. The liquid crystal display device using TFT includes a representative TN type (twist nematic), VAN type (vertical aligned nematic liquid crystal), IPS type (in-plane-switching), and other various types. In accordance with the above two types, the liquid crystal display element is place on an illumination device, and images are displayed by controlling transmission of polarized light from the illumination device. In estimating the light loss in a color liquid crystal display device, it has been found that the light loss by the polarizer alone is approximately 60%. In the case of a color display, the color filter loss in a display device provided with plane-divided color filters is equal to or more than 70%. Approximately 88% of light is lost by the arrangement including the polarizer and the color filters. Accordingly, even if the light loss generated for any other reason is eliminated, only approximately 12% of the projected light from the illumination device can

be utilized because of the absorption loss by the polarizer and the color filters. On the other hand, demands for the liquid crystal display device of note-type personal computer are not only thinness and lightness in weight, but also low power consumption and high brightness in the display. Furthermore, a demand for a decrease in power consumption for the display of a desk top computer and a work station is high. Accordingly, decreasing the power consumption of the liquid crystal display device is indispensable.

[0004]

Regarding the above issues, methods for decreasing the absorption loss of the polarizer and color filter in order to realize an improvement in brightness are disclosed in JP-A-6-130424 (1994) and JP-A-6-167718 (1994). In accordance with these methods, the efficiency of light utilization is improved by re-utilizing reflected light by controlling the reflection-transmission of circular polarized light in a specified direction of a specified wavelength by use of a cholesteric liquid crystal layer in order to utilize the light of the specified wavelength efficiently.

[0005]

[Issues to be solved by the invention]

In accordance with the references JP-A-6-130424 (1994) and JP-A-6-167718 (1994), a composition in which a color selection layer is arranged at both outside and inside of the substrate respectively is disclosed. Examples of the composition disclosed in the above references are shown in FIG. 30 and FIG. 31. In accordance with the structure indicated in FIG. 30, a liquid crystal 103 Is interposed between glass substrates 101, 104, a selective layer 100 Is arranged at the light projection side, a cholesteric layer 106, i.e. a color selective layer, and a filter layer 105 are arranged at the light incident side, and a light source

107 and a reflector 108 are arranged at rear side of the cholesteric layer 106. However, characteristics of the light source and others are not disclosed at all. In a case of this arrangement, wherein the cholesteric layer 106, i.e. the color selective layer Is arranged outside of the glass substrate 104, as indicated in FIG. 30, the projected light 110 viewed at an angle normal to the display surface does not have any problems such as mixing of colors in a color display, because the projected light passes through a dot wherein the cholesteric layer 106 and the liquid crystal 103 are the same (a region displaying the same color) . However, in a case where obliquely projected light 109 is viewed at an oblique angle, for instance, the light transmitted through a red (or green, blue) color selective layer 106 is controlled by a modulating signal for green (or blue) , i.e. an adjacent dot. Accordingly, when viewing at an oblique angle, the correct color is not necessarily displayed depending on the viewing angle, because of the thickness of the substrate 104 (generally the thickness of the glass substrate is 1.1 mm, or 0.7 mm and the dot pitch Is approximately 100 . m).

[0006]

In order to avoid the influence of the thickness of the glass substrate 104, an arrangement wherein the color selective layer 112 and a retardation film 111 are built-in has been proposed, as indicated in FIG. 31. Other constituents are the same as those indicated in FIG. 30. However, any problems concerning oblique incident light relating to the characteristics of the light source have not been considered. In the arrangement indicated in FIG. 31, the display is produced by controlling the polarization to the liquid crystal layer 103 by the color selective layer 112 and the retardation film 111, and controlling the polarization by the liquid crystal layer 103. However, the cholesteric liquid crystal layer used as the color selective layer 112 has an undesirable degree of

polarization to the oblique incident light, and, moreover, unnecessary light leakage of color is generated. That means that with respect to the oblique incident light, a polarization other than a desired polarization is generated, leakage of light via a color other than a desired color is generated, and so a deterioration in display quality represented by decreases in contrast ratio, color reproduction and viewing angle characteristics results.

[0007]

Then, one of the objects of the present invention is aiming to provide a color liquid crystal display device having a wide viewing angle and a high display quality, even if the display is viewed at an oblique angle, by eliminating any deterioration in display quality (unclearness) based on the thickness of the glass substrate and deterioration in display quality (decreased contrast ratio, deteriorated display color) at an oblique angle, which have been deemed as problems of prior art, thereby decreasing the absorption loss by the polarizer and the color filters, and improving the efficiency of light utilization..

[0008]

Other objects of the present invention will be clarified in accordance with the explanation of the embodiments of the present invention hereinafter.

[0009]

[Measures to solve the issues]

In order to realize the above objects, the following measures are used in accordance with the present invention. A liquid crystal display device is used, the device comprises a liquid crystal display element composed of a liquid crystal layer interposed between a pair of transparent substrates; an electric field applying means for controlling orientating direction of the liquid crystal layer; and an absorption type

polarized light selection means arranged on one of the pair of transparent substrates at light projecting side; and an illumination device arranged at rear side of the liquid crystal display element: wherein a light diffusion means is arranged on one of the pair of transparent substrates at light projecting side; a reflection type color selection means and a reflective polarizing selection means are arranged on one of the pair of transparent substrates at light incident side; and the illumination device provided with a reflecting means for reflecting reflected light from the reflection type color selection means and the reflection type polarizing means by projecting highly collimated light is arranged at the rear plane of the liquid crystal display element.

[0010]

First, the function of each of the means described above is explained hereinafter.

The electric field applying means is composed of electrodes for controlling orientation of the liquid crystal layer, circuits for applying voltage to the electrodes, and others. The display is performed by controlling the polarizing condition of the polarized light passing through the liquid crystal layer by controlling the orientation of the liquid crystal layer. The absorption type polarized light selection means is a so-called linear polarizer capable of absorbing unnecessary polarized light for transmitting one of the components of linearly polarized light intersecting in right angles each other and absorbing the other component of the linearly polarized light, or a so-called circular polarizer capable of absorbing unnecessary polarized light for transmitting one of two components of circularly polarized light and absorbing the other component of the circularly polarized light. The reflective polarizing selection means is a linear polarizer capable of reflecting unnecessary polarized light for transmitting a part of linearly polarized light

intersecting, for instance, at right angles with each other and reflecting the rest of the linearly polarized light, or a circular polarizer capable of reflecting unnecessary polarized light for transmitting a part of the circularly polarized light and reflecting the rest of the circularly polarized light. The reflective color selective means is a so-called color filter reflecting polarized light in an unnecessary wavelength region, which transmits a part of linearly polarized light (or circularly polarized light) having a specified wavelength (for instance, a center wavelength of 550 nm ± approximately 40 nm) and reflects linearly polarized light (or a circularly polarized light) in other wavelength regions. More details will be explained later with reference to various embodiments, but the reflective color selective means utilizes selective reflection of the cholesteric layer and characteristics of a multilayered dielectric film. The light diffusing means is a means for diffusing or diffracting incident light, such as, for instance, a diffusing medium having a hologram or non-uniform index of refraction. The light diffusing means desirably maintains the polarization of the polarized light and has a role to make the viewing angle wide by broadening the projected light having a high collimation from the illumination device at the projecting side of the liquid crystal display element. A means for increasing collimation of the projected light at the illumination device comprises, for instance, a wedge shaped waveguide having stripes of microgrooves at its rear plane, and an arrangement of a lens sheet having stripes of triangle shapes intersecting with stripes of grooves as the light control means on the waveguide. Thereby, the projected light having a high collimation in a direction perpendicular to the direction of the stripes can be obtained by the stripes of the microgrooves of the waveguide and furthermore, the collimation in a direction intersecting with the above projected light can be improved by the use of the lens sheet. Accordingly, the illumination

device having a high collimation at all azimuth angles can be obtained. Other methods for collimation will be clarified later by the embodiments.

[0011]

When the collimated light from the illumination device Is undesirable, the problems caused by unclearness of the displayed image and the mixing of colors are as indicated in the embodiment shown in FIG. 30 and FIG. 31. Therefore, the collimated light from the illumination device is important for obtaining a clear image display. Using the liquid crystal display element indicated in FIG. 32, necessary collimation of the light source was investigated. First In accordance with the present invention, a structure is composed by arranging the liquid crystal layer 13 between the transparent substrates 12, 14, at the projection side of which, the absorption type polarizing selection layer 10 and the light diffusing layer 10 are arranged; and at the incident side thereof, the retardation film 16, i.e. a reflective color selection layer 30, and cholesterlc layer 17 are arranged. Here, the thickness 12t, 14t of the transparent substrates 12, 14 are both t, the dot pitch 13A is d, the incident angle 130 of the incident light to the liquid crystal display element 40 is expressed by . $_1$, the incident angle 131 of the incident light to the transparent substrate 14 is expressed by . $_2$, and the index of refraction of the transparent substrates 12, 14 are both expressed as n. Here, three dots of R, G, and B are arranged to form a pixel. Generally, one dot had a ratio of vertical direction to lateral direction of 3 : I and the short side of the dot was designated as the dot pitch d. The color mixing and the unclearness based on the thickness of the substrate by oblique incident light must be restricted in at least two dots at an angle where the brightness is 1/2 of the peak brightness. Otherwise, the displayed image becomes unclear. Accordingly, the incident angle . $_1$ of the incident light must satisfy the following equation (1):

[0012]

[math. 2]

$$. _{1} .\ \sin^{-1}(n\sin(\tan^{-1}(2/dt))) \qquad ...\ (1)$$

[0013]

Assuming that the refractive index of the transparent substrate n = 1.53, the thickness t = 700 . m, and the dot pitch d = 100 . m, the incident angle . $_1$ of the incident light must be equal to or less than 24.9 degrees. Otherwise, the incident light will overlap with dots of other colors, and a decrease of the image quality, such as color mixing, unclearness, and the like, will be generated. Accordingly, the collimated light from the illumination device must be in an angular range which satisfies the condition expressed by the equation (1) with at least a half width (an angular range of brightness which is 1/2 of the peak brightness) . Therefore, with the transparent substrate and pixel used in the present embodiment, an incident angle equal to or less than 24.9 degrees is necessary.

[0014]

Next, the functions of the reflective color selection means 30, and the reflective polarizing selection means 31 are explained in detail referring to FIG. 2. As one of examples of the reflective color selection means 30, the cholesteric layer 17A~17C utilizing specific reflection of cholesteric and the retardation film 16 operating as 1/4 wavelength to each wavelength are used. The retardation film 16 may be arranged for each color as well as the choresteric layer 17 so as to operate as 1/4 wavelength for respective of colors. As the reflective polarizing selection means 31, for instance, a cholesteric layer 18A having a specific reflection to at least three primary colors is used, and the layer is

twisted reversely to the cholesteric layer 17A~17C. The cholesteric layer 17A~17C as the reflective color selection means 30, the retardation film 16, and the cholesteric layer 18A as the reflective polarizing selection means 31 are arranged on the illumination device composed of the waveguide means 22 and the reflection means 21.

Utilization of the cholesteric layer 18A as the reflective polarizing selection means 31 is well known to the public, and technology disclosed in JP-A-3-45906 (1991) and JP-A-6-324333(1994) can be used. The specific reflection wavelength . = (n_0 + n_e)/ 2P is determined by spiral pitch of the cholesteric P, and refractive index of the material in normal direction n_0 and in abnormal direction n_e , and the specific reflection band region . . = . nP is determined by an anisotropy of refractive index . n = n_e - n_0 and the spiral pitch P. However, because . n is at most 0.3 and all visible region can not be covered, it is supported by stacking cholesteric layers having different pitches each other, or pitch itself is varied in a cholesteric layer. The cholesteric layer 17A~17C as the reflective color selection means 30 can be used as the same materials as for the reflective polarizing selection means 31, and the spiral pitch of each of layers is set so as to perform specific reflection of red, green or blue, respectively. The center of wavelength of the specific reflection, and the specific reflection band region are not restricted, but, each of the center of wavelength is desirably set at 470 nm, 550 nm, and 620 nm, respectively, and the specific reflection band region is set desirably at ±35 nm.

[0015]

Conveniently in explanation, it is assumed that the cholesteric layers 17A~17C are right twisted, and the cholesteric layer 18A is left twisted. Accordingly, the cholesteric layer 18A reflects left circular polarized light in the visible light region, and transmits right circular

polarized light. Each of the cholesteric layers 17A, 17B, and 17C, reflects red right circular polarized light, green right circular polarized light, and blue right circular light, respectively, and transmits other light.

[0016]

The projected light 200, i.e. white non-polarized light, from the waveguide means 22 composed of transparent acrylic resin is entered into the cholesteric layer 18A, i.e. the reflection type polarized light selection means, and the transmitted light becomes white right circular polarized light 201, and the reflected light becomes white left circular polarized light 203. The white right circular polarized light 201, i.e. the transmitted light, is projected into the cholesteric layers 17A, 17C, green right circular polarized light 202 is transmitted through, and blue and red right circular polarized light 206 are reflected. The transmitted green right circular polarized light is converted by the retardation film 16 to green linear polarized light 213.

[0017]

The reflected white left circular polarized light 203 is converted to left circular polarized light by reflecting at the reflective means 21 arranged at rear of the waveguide, and transmits the cholesteric layer 18. The white right circular polarized light transmitted through the cholesteric layer 18A is projected into the cholesteric layers 17B, 17C, and only red right circular polarized light 205 transmits, and other right circular polarized light are reflected. The transmitted right circular polarized light 205 is converted to red linear polarized light 214 having the same direction as the green linear polarized light 213 by the retardation film 16.

[0018]

The reflected blue and red right circular polarized light 206 is reflected by the reflection means 21 to be blue and red left circular

polarized light 207, further reflected by the cholesteric layer 18A without any change, i.e. as left circular polarized light, and further reflected by the reflection means 21 to be right circular polarized light 209. The right circular polarized light 209 transmits the cholesteric layer 18A, and is projected into the cholesteric layers 17A, 17B. Only blue right circular polarized light 210 transmits the cholesteric layer, and other light are reflected. The transmitted blue right circular polarized light 210 is converted to linear polarized light 215 having the same direction as the linear polarized light 213, 214 by the retardation film 16. Here, the present invention has been explained taking a case as an example when the waveguide means 22 and the reflection means 21 do not resolve polarized light by diffusing. However, in a case when resolution of polarized light is existed, re-utilization of light is performed by repeating the transmittance of only desired polarized light and reflection of undesired polarized light.

[0019]

The reflected light 211, 212, from the cholesteric layer, i.e. the reflective color selection layer, are re-utilized by the same phenomenon described above.

[0020]

The functions of reflective color selection means 30 and reflection type polarized light selection means 31 are explained hereinafter referring to FIG. 3. As an example of the reflection type color selection means 30, dielectric multilayered film 19A ~19C, which transmits one of linear polarized light of each colors intersecting normally each other and reflects the other linear polarized light, are utilized. As an example of the reflection type polarized light selection means 31, dielectric multilayered film 18B, which transmits one of linear polarized light of three primary colors intersecting normally each

other and reflects the other linear polarized light, is utilized. The dielectric multilayered film 19A ~ 19C and the dielectric multilayered film 18B are arranged so that their polarized directions are intersecting normally each other. The dielectric multilayered film 19A ~ 19C as reflection type color selection means 30 and the dielectric multilayered film 18B as reflection type polarized light selection means 31 are arranged on the illumination device which comprises the waveguide means 22 and the reflection means 21. Desirably, the retardation film 16A which operates as 1/4 wavelength for each wavelength is arranged between the dielectric multilayered film 18B and the reflection means 21. Further desirably, the retardation film 16A is in stripe shape coinciding with the layer of the reflection type color selection means in order to adjust retardation to each colors.

[0021]

Utilization of the dielectric multilayered film 18B as the reflection type polarized light selection means 31 is well known to the public, and related technology disclosed in WO95/27919 can be applied. The dielectric multilayered film 19A ~ 19C as reflection type color selection means 30 can be composed of the same materials as the reflection type polarized light selection means 31, and each of the layer is set to transmit one of the linear polarized light of normally intersecting linear polarized light of red, green, and blue, and to reflect the other linear polarized light.

[0022]

Conveniently in explanation, linear polarized light in a direction perpendicular to drawing is expressed as +, and in a lateral direction along the drawing is expressed as . . projected light 200A, i.e. white non-polarized light, from the waveguide means 22 which is composed of transparent acrylic resin is projected into the dielectric multilayered film

18B, i.e. a reflection type polarized light selection means, and transmitted light becomes white + linear polarized light 201A, and reflected light becomes white . linear polarized light 203A. The white + linear polarized light 201A, i.e. transmitted light, is projected into the dielectric multilayered film 19A, 19C. Then, green + linear polarized light 202A is transmitted, and green, blue + linear polarized light 209A is reflected.

[0023]

On the other hand, the reflected white linear polarized light 203A is converted to right circular polarized light 204A by the retardation film 16A, reflected by the reflection means 21 arranged at rear plane of the waveguide means 22 to be left circular polarized light 205A, and transmitted through the retardation film 16A again to be converted to + linear polarized light 206A, and transmitted through the dielectric multilayered film 18B to be + linear polarized light 207A. The + linear polarized light 207A transmitted the dielectric multilayered film 18B is projected into the dielectric multilayered film 19B, 19C, only red + linear polarized light 208A is transmitted, and the other + linear polarized light 218A is reflected and re-utilized by the same theory.

[0024]

The reflected blue, red linear polarized light 209A is converted to left circular polarized light 210A by the retardation film 16A, reflected by the reflection means 21 to be blue, red right circular polarized light 211A, and projected into the retardation film 16A again to be converted to . linear polarized light 212A, reflected by the dielectric multilayered film 18B, and the reflected . linear polarized light 213A is transmitted through the dielectric multilayered film 16A to be right circular polarized light 214A, reflected by the reflection means 21 to be left circular polarized light 215A, again transmitted through the

retardation film 16A to be + linear polarized light 216A, and transmitted through the dielectric multilayered film 18B. The + linear polarized light 216A, i.e. the transmitted light, is projected into the dielectric multilayered film 19A, 19B, only blue + linear polarized light is transmitted, and the other light is reflected to be the reflected light 219A, and is re-utilized by the same theory. Here, explanation has been performed on the case when the waveguide means 22 and the reflection means 21 do not have any diffusing effect to resolve polarized light. However, in a case when resolution of polarized light is existed, re-utilization of light is performed by repeating the transmittance of only desired polarized light and reflection of undesired polarized light.

[0025]

Hitherto, operations of the reflection type color selection means 30 and the reflection type polarized light selection means 31 have been explained referring to FIG. 2 and 3, but, the cholesteric layer can be used as the means 30 and the dielectric multilayered layer can be used as the means 31, or the dielectric multilayered film can be used as the means 30 and the cholesteric layer can be used as the means 31. Thus, the present invention is not restricted by the explanation.

[0026]

Furthermore, visual angle characteristics of the reflection type polarized light selection means 31 explained previously referring to FIG. 2 and FIG. 3 is generally worse in comparison with an absorption type polarizer (polarized condition will be shifted from a desired condition by obliquely incident light). Accordingly, if necessary in consideration of the collimation degree of the illumination device, an absorption type polarized light selection means 15 is desirably arranged at incident light plane of the liquid crystal display element as shown in FIG. 13. Furthermore, the visual angle characteristics of the reflection type color

selection means 30 is generally undesirable because the polarized condition will be shifted from a desired condition by obliquely incident light. Accordingly, if necessary in consideration of the collimation degree of the illumination device, a color filter as an absorption type color selection means is desirably arranged in the liquid crystal display element as shown in FIG. 25.

[0027]

Furthermore, display having a wide visual angle and no color-mixing among reflection type color selection means can be realized by arranging the reflection type color selection means in a stripe shape, using an illumination device having a directivity in a direction intercrossing normally to the direction of the stripe shape, and diffusing on the displaying plane only in a direction having the directivity. In accordance with arranging the reflection type color selection means in a stripe shape, deterioration of image display by color mixing among pixels can be prevented without providing the directivity in a direction of the stripe shape. In accordance with increasing the collimation degree of the illumination device only in a direction, not only the amount of projected light and incident light of the illumination device itself can be increased, but also its structure can be simplified. For instance, A lens sheet can be omitted by setting the stripe microgrooves of the illumination device approximately parallel to the direction of the stripe of the reflection type color selection means.

[0028]

Further, a display having high color re-productivity with obliquely incident light can be obtained by arranging a second absorption type polarized light selection means at liquid crystal layer side of the reflection type color selection means in order to compensate a change in characteristics (color change, polarizing light change) of the reflection

type color selection means with obliquely incident light. Even if spread of light from the light source in a direction of stripe is existed, not only issues such as color mixing is eliminated because the color in the stripe direction has the same color, but also orientation can be increased without deteriorating the utilization efficiency of light, and accordingly, a color liquid crystal display device having a high light utilization efficiency can be realized.

[0029]

Further preferably, a display having a high display quality even with obliquely incident light from a direction which is not the diffusing direction by the diffusing film at display plane side by using a liquid crystal display mode having a wide visual angle in a direction of stripe of the reflection type color selection means. Further preferably, composition of the illumination device can be simplified by arranging the longitudinal direction of the lamp substantially parallel to the stripe direction of the reflection type color selection means.

[0030]

In accordance with using the means described above, deterioration of image quality, deterioration of display performance such as contrast ratio to obliquely incident light, display colors, and others caused depending on the thickness of the substrate, which have been regarded as problems, can be prevented, and a bright display device of small absorption loss and low consuming power can be obtained. That is, in accordance with increasing the collimation of the light source at all azimuth angles high and arranging a light diffusing means at light projecting side of the liquid crystal display element, transmitting light of the reflection type color selection means and the liquid crystal layer is made transmit through the substrate substantially normally and made light diffuse at display plane to realize a wide visual angle. Therefore,

the issues relating to obliquely incident light, which have been serious problems for a long time, have been resolved, and a display device of wide visual angle having no deterioration of image quality by visual angle can be obtained. Furthermore, increase in efficiency by re-utilization of light can be achieved, because reflected light from the reflection type color selection means and the reflection type polarized light selection means can be utilized efficiently.

[0031]

Other means and operations of the present invention will be clarified by the following embodiments.

[0032]

[Description of preferred embodiments]

First, an embodiment of the present invention is explained referring to FIG. 1. The liquid crystal display device of the present invention comprises an illumination device 20 having a strong directivity (strong collimation) in a lateral direction of this page, a cholesteric layer 31 as a reflection type polarized light selection means, a two layered cholesteric layer 17 twisted reversely to the cholesteric layer 31 as a reflection type color selection layer 30, a retardation film 16 operating as 1/4 wavelength film, and a light diffusing layer 11 maintaining polarized light as a light diffusing means provided upside of the liquid crystal display element 40. As for light diffusing layer 11, light control film made by Sumitomo Chemicals Co. (commercial name: LUMISTY) was used. The light control film made by Sumitomo Chemicals Co. is a prior art disclosed in the reference, Sumitomo Chemicals, 1991, p37-p48 "A high polymer having a light control function-LUMISTY". In accordance with FIG. 1, the reflection type color selection layer 30 transmits specified polarized light having a specified wavelength, and reflects the specified polarized light having the other wavelength. For instance,

one of three primary colors (red, green, blue) is transmitted, and other colors are reflected. The cholesteric layer 31 transmits one of circular polarized light at least in the visual wavelength region, and reflects other circular polarized light. In accordance with arranging the cholesteric layer 31, the reflection type color selection layer 30, and the liquid crystal display element 40 on the illumination device 20, the reflected light from each layers 30, 31 can be re-utilized as described previously, and a liquid crystal display device having a low absorption loss and high light utilization efficiency can be realized.

[0033]

As for the illumination device of the present invention, an edge-light type back light or a direct below type back light is used. The direct-below type back light is composed so that light sources are provided inside the illuminating plane. On the other hand, the edge-light type back light is composed so that light sources are provided outside the illuminating plane. The waveguide, i.e. forming the illuminating plane, is made of a transparent acrylic resin and the like, cylindrical light-sources are arranged at one-side or two sides of the waveguide and lamp covers composed of reflectors 24 are arranged outside of the light-sources for projecting light into the waveguide. As the lamp light source, a fluorescent lamp having an illuminating length corresponding to the size of the display device is used. In order to make the lamp have a directivity at least in an axial direction, a definite microgrooves are provided in a vertical direction to the drawing at the rear plane of the waveguide 22 as shown in FIG. 1, and a metal having a high reflectivity (aluminum, silver, and the like) is arranged as back side reflector 21. Among light projected from the light source 23, the incident light component into the left oblique portion at rear plane of the waveguide 22 is reflected and projected upward as light having a strong directivity

(lateral direction of the drawing). The incident light into the right oblique portion is guided in the waveguide 22 to make inside of the plane uniform.

[0034]

In accordance with the present embodiment, the illumination device 20 shown in the perspective drawing FIG.4 and the cross sectional drawing FIG. 5 was used. The light source 23 is extended long in a direction perpendicular to the drawing, reflectors 24 are arranged around thereof, and projected light 23A from the light source 23 is conducted to the waveguide 22. A cold cathode fluorescent lamp was used as the light source, but the light source is not restricted to the fluorescent lamp. As described previously, in order to eliminate color mixing by obliquely incident light, it is necessary to make the light source have a directivity at least in a direction lateral to the drawing. Therefore, a fine microgrooves structure was formed at the rear plane of the waveguide 22, which was made of transparent acrylic resin, to make light projected from the waveguide 22 have a directivity in a direction lateral to the drawing. Among the incident light to the waveguide 22, the incident light to the left oblique portion of the microgrooves is reflected with the oblique angle A 22A, and projected as the projected light 23C from the waveguide 22. On the other hand, the incident light to the right oblique portion of the microgrooves is totally reflected with the oblique angle B 22B, and is propagated to the right direction of the drawing as conducted light 23B, and the light is projected as projected light 23C only when projected to the right oblique portion of the drawing. The micro structure at the rear plane of the waveguide 22 was formed with 200 . m as the pitch 22C, 40 degrees as the oblique angle A 22A, and 3 degrees as the oblique angle B 22B. However, each of the pitch and oblique angles are not restricted with these values if the pitch 22C is

in the range of approximately 10 . m to 1000 . m, the oblique angle A 22A is in the range of approximately 20 degrees to 50 degrees, and the oblique angle B22B is in the range of approximately zero degrees to 20 degrees. The characteristic of the projection from the illumination device 20 has a strong directivity in a direction lateral to the drawing as shown qualitatively in FIG. 4, and no directivity in a direction perpendicular to the drawing. The projection characteristics of the illumination device used in the present embodiment is shown in FIG. 21. The projection characteristics in a direction perpendicular to the drawing is 25A, in a lateral direction to the drawing is 25B, and the illumination device having a strong directivity in an axial direction could be realized. The illumination device 20 is not restricted to the present embodiment if the device has a strong directivity in an axial direction (a direction perpendicular to the stripe of the reflection type color selection layer 30) .

[0035]

As for a liquid crystal display element 40, a liquid crystal layer 13 is interposed between a pair of transparent substrates 12, 14, and an absorption type polarized light selection layer 10 and a light diffusing layer 11 are arranged on the transparent substrate 12 at light projection side. The liquid crystal layer 13 was a twisted nematic layer having a ninety degrees twist, and its anisotropy of refractive index . nd was 0.4 . m. The transparent substrates 12, 14 were made of Corning glass substrate 7059, and its thickness was 0.7 mm. The light diffusing layer 11 is required to maintain polarized light when it is arranged inside of the absorption type color selection layer 10, and LUMISTY made by Sumitomo Chemicals Co. was used in preparation of the light diffusing layer as described previously. As for polarized light selection layer 10, a polarizer G1220DU made by Nitto Denko Co. was used. In

accordance with FIG. 1, orientation film, electrodes for applying electric field to the liquid crystal layer 13, switching elements, wiring, and the others are omitted, in order to align the liquid crystal in a direction. The size of each dot of RGB was 100 . m x 300 . m, respectively. As for the liquid crystal layer 13, an initial orientation (no voltage is applied) of homogenous orientation, twisted orientation, and homeotropic orientation can be used. Liquid crystal having a positive dielectric anisotropy is used for homogenous orientation and twisted orientation, and liquid crystal having a negative dielectric anisotropy is used for homeotropic orientation. As for twisted orientation, 90 degrees twisted orientation is representative, but it is not restricted to 90 degrees. An axis of arranging the polarizer, orientating direction of the liquid crystal and others is determined so that a wide visual angle can be achieved at least in a direction perpendicular to the drawing FIG. 1, as stated later.

[0036]

In accordance with conventional illumination device, problems such as unclearness of image, and color mixing were generated. Therefore, the reflection type color selection layer 30 was made to have a stripe shaped structure in a direction perpendicular to the drawing in matching with the pitch of the liquid crystal layer 13 (the pitch was 100 . m in matching with the pixel (dot)). The illumination device 20 used in the present invention has a strong directivity in a lateral direction of the drawing, that is, a highly collimated light projection characteristics. Accordingly, because of high collimated light in a direction perpendicular to the stripe of the reflection type color selection layer 30, the light transmitted through the reflection type color selection layer 30 passes dots corresponding to a same color of the liquid crystal display element, and the light is diffused to the lateral direction of the drawing by the upper light scattering layer 11. Then, wide visual angle display having

no unclearness of images, no decrease in contrast, nor decrease in color purity could be obtained. On the other hand, in a direction perpendicular to the drawing, the light source is not necessarily required to project highly collimated light in order to display a same color. In order to look the projected light from the illumination device 20 without making be diffused, the projected light from the illumination device 20 is made to be diffused only in a direction of strong directivity, but not in a direction perpendicular to the strong directivity even by the light scattering layer 11. Therefore, if the collimation is enhanced at least in a direction perpendicular to the stripe of the reflection type color selection layer 30, color mixing caused by the thickness of the glass substrate can be eliminated, display with a wide visual angle can be realized. The projection characteristics at displaying white is shown in FIG. 23. The perpendicular direction to the drawing is the direction not scattered by the light scattering layer 11, and the characteristics in a direction perpendicular to the drawing 25E reflecting the projecting characteristics of the illumination device 20 could be obtained. In a direction lateral to the drawing, the incident light is scattered by the light scattering layer 11 after transmitting the liquid crystal layer 13, and the characteristics of 25F was obtained. In accordance with the present embodiment, the characteristics of no color mixing, high contrast ratio could be obtained.

[0037]

As explained above, a wide visual angle display without any unclearness of images can be realized by the present embodiment. Light utilization efficiency was significantly increased, because conventional absorption loss by polarizer, color filter was decreased. First, projected light from the waveguide 22 is no-polarized light, but one of circular polarized light is transmitted through the cholesteric layer 31,

and the other circular polarized light is reflected. The transmitted circular polarized light is selected in color by the reflection type color selection layer 30, and only the circular polarized light of desired color is transmitted (undesired color is reflected). Then, the light is converted to linear polarized light by the retardation film, modulated in polarized light by the liquid crystal layer 13, selected by the absorption type polarized light selection layer 10, and a display corresponding to image signal is displayed. On the other hand, the other circular polarized light reflected by the cholesteric layer 31 is reflected by the reflector 21 arranged at rear plane of the waveguide to be reversely circular polarized light, and is transmitted through the cholesteric layer 31 to be utilized for display as well. In the same manner, the reflected light of undesired color can be re-utilized when the light is entered into a desired color selection layer after repeating reflection by the reflector arranged at rear plane of the waveguide 21. Accordingly, although the reflector 21 and the selection layer 30, 31 cause some absorption loss, almost all light can be re-utilized theoretically, and light utilization efficiency can be increased significantly. In accordance with the present embodiment, the light utilization efficiency could be increased to approximately 3.5 times in comparison with a case when the cholesteric layer 31 and the color selection layer 30 are not used.

[0038]

Next, an embodiment of illumination device having a high collimation at an axis direction and all azimuth direction is explained hereinafter.

[0039]

As an embodiment of illumination device 20A, the illumination device 20 shown in FIG. 6 was used. Using a stripe shaped lens sheet 26 having a triangle cross section on the illumination device 20, a

characteristics having a directivity in a direction deep to the drawing was obtained. In accordance with the present embodiment, the top angle 26A was 90 degrees, and the pitch was 50 . m. However, the present invention is not restricted by these values. As the result, the directivity was strengthened in all azimuth direction as indicated by 300A in lateral direction projecting characteristics, and 301A in perpendicular direction projecting characteristics, and the collimation was improved. The projection characteristics in this case is shown in FIG. 22. The lateral direction projection characteristics 25D was somewhat broadened, but directivity in the perpendicular projection characteristics 25C was increased. In accordance with applying the illumination device 20A to the color liquid crystal display device shown in FIG. 1, obliquely incident light in a direction of stripe of the reflection type color selection layer could be decreased in addition to improvement of front brightness by directivity, and color re-productivity in visual angle was improved. In accordance with arranging LUMISTY made by Sumitomo Chemicals Co. in a manner that the direction of its light diffusing axis are intercrossed normally each other as the light diffusing layer 11, transmitting light of the liquid crystal layer 13 could be broadened in all azimuth direction, and the visual angle characteristics could be improved. The visual angle characteristics of white display in this case is shown in FIG. 24. The light was scattered by the light diffusing layer 11 in both perpendicular direction and lateral direction of the drawing, and visual angle characteristics in perpendicular direction of the drawing 25G and lateral direction of the drawing 25H were obtained. In accordance with the present embodiment, the characteristics having no color mixing in images and a high contrast ratio could be obtained. In comparison with the characteristics shown in FIG. 23, the front brightness was increased to 1.3 times, and a visual angle characteristics of almost equal in all

azimuth direction could be obtained.

[0040]

An embodiment of illumination device 20B which was applied with the collimate sheet 27A shown in FIG. 7 instead of lens sheet 26 is shown in FIG. 8. The collimate sheet 27A was made of transparent acrylic resin having a stripe shape and narrower bottom, and the shape of pitch 4 mm, height 4 mm, and bottom side 1 mm was used. The shape was not restricted by these values, if the structure has a narrow bottom and the size is broadened as closing to the upper surface. As the result, the incident light at the bottom plane of the collimate sheet 27A obtained the characteristics in which the directivity was improved only in a lateral direction of the drawing as shown 300B, and broadened characteristics reflecting the incident light visual angle characteristics shown as 301B in a deep direction of the drawing. The collimate sheet 27A was arranged so that the direction of its stripe was intercrossed normally with the direction of grooves of the illumination device 20, and the interval between the waveguide 22 and the collimate sheet 27A was combined with a transparent medium having almost equal refractive index. As the result, only the light reflected by the declined microgroove portion at rear plane of the waveguide 22 was projected, and the other light, which might be all reflected and guided in the waveguide 22 if the collimate sheet was not existed, would be projected when the light entered at the bottom plane of the collimate sheet 27A. Accordingly, the projection characteristics in the lateral direction 300C is collimated by the microgrooves at the rear plane of the waveguide 22, and the projection characteristics in the perpendicular direction 301C is collimated by the collimate sheet 27A. Desirably, the collimate sheet 27A is adhered by not all the bottom region, but by bottom with definite intervals parallel with the microgrooves at rear plane of the waveguide

22. In accordance with applying the illumination device 20B to the color liquid crystal display device shown in FIG. 1, obliquely incident light in a direction of stripe of the reflection type color selection layer could be decreased in addition to improvement of front brightness by directivity, and color re-productivity in visual angle was improved.

[0041]

In order to collimate the projection light in all azimuth direction of the illumination device, the collimate sheet 27B shown in FIG. 9 is used. The collimate sheet 27B is made of transparent acrylic resin having a rectangular bottom and top planes, and narrower bottom, although the collimate sheet 27A has a stripe shape arrangement, and the shape of pitch 4 mm, height 4 mm, and bottom side 1 mm was used. The shape was not restricted by these values, if the structure has a narrow bottom and the size is broadened as closing to the upper surface.

[0042]

The illumination devices 20C and 20D using the collimate sheet 27B are shown in FIG. 10 and FIG. 11, respectively. FIG. 10 shows a side light type illumination device 20C applied with the collimate sheet 27B, and the interval between the waveguide 22 and the collimate sheet 27B is adhered with a transparent medium having almost equal refractive index. As the result, only incident light to the bottom plane of the collimate sheet 27B among all the reflected light in the waveguide 22 is projected, and the characteristics of the projection light becomes to have directivity in the lateral direction 300E, and in the perpendicular direction 301E. FIG. 11 shows a direct-below type illumination device 20D applied with collimate sheet 27B, and the portions other than the bottom plane portion of the collimate sheet 27A are made of reflector. Therefore, collimation could be increased not only in an axial direction, but also in all azimuth direction.

[0043]

Next, another embodiment of liquid crystal display element 40 is explained hereinafter.

[0044]

An embodiment of liquid crystal display element 40 is shown in FIG. 12. The illumination device 20 had the structure equivalent to the structure shown in FIG. 1, but any one of illumination devices 20A, 20B, 20C, and 20D can be used. The different point from the embodiment shown in FIG. 1 is in the arrangement of the reflection type color selection layer 30 and the reflection type polarized light selection layer 31. In the present embodiment, the reflection type color selection layer 30 and the reflection type polarized light selection layer 31 were arranged at inside of the transparent substrate 14. The arrangement of the reflection type color selection layer 30 at inside of the transparent substrate 14 is important feature, and the reflection type polarized light selection layer 31 may be arranged at illumination device side of the transparent substrate 14, because matching of pixels (dots) is not necessary. In accordance with FIG. 1, thickness of the transparent substrates 12, 14 is the origin of unclearness of images. that is, if collimation of the projected light from the illumination device is insufficient, dots of the reflection type color selection layer 30 and the liquid crystal layer 13 passes through different regions each other, and color mixing is generated. However, in accordance with making the structure as the present embodiment, the effect of thickness of the transparent substrate 14 can be eliminated, clear images can be obtained even if collimation of the illumination device 20 is insufficient.

[0045]

An embodiment of liquid crystal display element 40 is shown in FIG. 13. The illumination device 20 had the structure equivalent to the

structure shown in FIG. 1, but any one of illumination devices 20A, 20B, 20C, and 20D can be used. The different point from the embodiment shown in FIG. 1 is in the arrangement of the absorption type polarized light selection layer 15, which is arranged between the transparent substrate 14 and the reflection type color selection layer 30. A polarizer G1220DU made by Nitto Denko Co. was used as the absorption type polarized light selection layer 15. In the present embodiment, cholesteric layer were used as the reflection type color selection layer 30 and the reflection type polarized light selection layer 31, and a polarizing degree and dependency of polarized light on visual angle were worse in comparison with the absorption type polarized light selection layer. Therefore, unnecessary polarized light from the layers 30 , 31 are absorbed by the absorption type polarized light selection layer 15 by arranging the absorption type polarized light selection layer 15 onto the reflection type polarized light selection layer 31 and the reflection type color selection layer 30, and polarized characteristics of the transmitted light can be improved and the contrast ratio of the display can be improved.

[0046]

An embodiment of liquid crystal display element 40 is shown in FIG. 14. The illumination device 20 had the structure equivalent to the structure shown in FIG. 12, but any one of illumination devices 20A, 20B, 20C, and 20D can be used. The different point from the embodiment shown in FIG. 12 is in the arrangement of the absorption type polarized light selection layer 15, which is arranged between the reflection type color selection layer 30 and the liquid crystal layer 13. A polarizer G1220DU made by Nitto Denko Co. was used as the absorption type polarized light selection layer 15. In the present embodiment, cholesteric layer were used as the reflection type color selection layer 30

and the reflection type polarized light selection layer 31, and a polarizing degree and dependency of polarized light on visual angle were worse in comparison with the absorption type polarized light selection layer. Therefore, unnecessary polarized light from the layers 30 , 31 are absorbed by the absorption type polarized light selection layer 15 by arranging the absorption type polarized light selection layer 15 onto the reflection type polarized light selection layer 31 and the reflection type color selection layer 30, and polarized characteristics of the transmitted light can be improved and the contrast ratio of the display can be improved. Furthermore, in accordance with FIG. 13, thickness of the transparent substrates 12, 14 is the origin of unclearness of images. that is, if collimation of the projected light from the illumination device is insufficient, dots of the reflection type color selection layer 30 and the liquid crystal layer 13 passes through different regions each other, and color mixing is generated. However, in accordance with making the structure as the present embodiment, the effect of thickness of the transparent substrate 14 can be eliminated, clear images can be obtained even if collimation of the illumination device is insufficient.

[0047]

An embodiment of liquid crystal display element 40 is shown in FIG. 25. The different point from the embodiment shown in FIG. 13 is in the arrangement of the absorption type color selection layer 32, which is arranged in the vicinity of the liquid crystal layer 13. A color filter which has been used conventionally for current TFT-LCD and others was used as the absorption type color selection layer 32. A polarizer G1220DU made by Nitto Denko Co. was used as the absorption type polarized light selection layer 15. In the present embodiment, a cholesteric layer was used as the reflection type color selection layer 30, and a color selectivity and dependency of the color selectivity on visual

angle were worse in comparison with the absorption type color selection layer. Therefore, unnecessary polarized light from the layer 30 can be absorbed by the absorption type color selection layer 32 by arranging the absorption type color selection layer 32, and color purity of the transmitted light can be improved and color re-productivity of displayed color can be improved.

[0048]

An embodiment of liquid crystal display element 40 is shown in FIG. 26. The present technology can be applied to the embodiments shown in FIg.1, FIG. 12, FIG. 13, FIG. 14, and FIG. 25, and the pitch of the cholesteric layer 17 forming the reflection type color selection layer 30 was set 200 . m, i.e. two times of the dot pitch. Two of the cholesteric layers 17 were composed in a manner to shift a half pitch each other, and each of 17A, 17B, and 17C was a cholesteric layer showning a specific reflection of green, red, and blue, respectively. In accordance with making the pitch of the cholesteric layer 17 twice as described above, manufacturing process could be simplified.

[0049]

Next, an embodiment of diffusing layer 11 is explained hereinafter.

[0050]

An example of the characteristics of the light diffusing layer 11A is shown in FIG. 15. In accordance with the previous embodiments, as for the light diffusing layer 11A, LUMIST made by Sumitomo Chemicals Co. was used as the uniaxial light diffusing layer having a characteristics that has a scattering property in the lateral direction such as 302A, and no scattering property in the perpendicular direction such as 303A. In accordance with the present embodiment, a stripe shaped rod lens array (pitch was approximately 50 . m) shown in FIG. 15 was used as the light

diffusing layer 11B having uniaxial scattering property. The other members had as same structures as the embodiments shown in FIG. 13 or FIG. 14. The illumination device 20 used in the present embodiment had a strong directivity in the lateral direction, and display of clear and wide visual angle could be realized by broadening the light after transmitting the liquid crystal layer 13 by the uniaxial light diffusing layer 11B.

[0051]

Next, as an embodiment of light diffusing layer 11C, the light diffusing layer having a characteristics having scattering property in all azimuth direction as shown in FIG. 17 was used. A micro-lens array (pitch was approximately 50 . m) shown in FIG. 18 was used as the light diffusing layer 11D. An illumination device having high collimation in all azimuth direction shown in FIG. 8 was used as the illumination device 20B. The other members had as same structures as the embodiment shown in FIG. 16. As the result, collimation in all azimuth direction was increased by the illumination device 20B, each of the layers 13, 15, 30, and 31 was transmitted perpendicularly, and a display of clear and wide visual angle was realized by broadening the light by the light diffusing layer 11D located at upper portion.

[0052]

Furthermore, as for the light diffusing layer, a diffuser having diffusivity in all azimuth direction could be prepared by making the previously described uniaxial light diffusing layers 11F and 11E so that each of their diffusing directions were intercrossed approximately normally as shown in FIG. 19. The diffuser was applied to the structure shown in FIG. 18, and a display of clear and wide visual angle could be realized. Spherical beads 11G2 shown in FIG. 20 were arranged, absorbers 11G1 were arranged in the intervals of the beads, and a low

refractive index layer 11G3 having lower refractive index than the beads 11G2 was formed in order to increase incident efficiency to beads. As the result, a light diffusing layer 11G having light diffusivity in all azimuth direction could be realized. By applying the light diffusing layer 11G to the device shown in FIG. 18, a display of clear and wide visual angle could be realized.

[0053]

Next, an embodiment of display mode of liquid crystal display element is explained hereinafter.

[0054]

In order to eliminate color mixing caused by a reflection type color selection layer substantially, an illumination device having a directivity at least in a direction intercrossing normally with stripe direction of the reflection type color selection layer was used, and a structure was composed so that the light is diffused only in the direction of its directivity at the upper plane of the liquid crystal display element. In accordance with this structure, color mixing in the direction parallel to the stripe direction can be prevented because only a same color is displayed, and no directivity is required. However, when viewing obliquely from the stripe direction, the characteristics itself of the liquid crystal display element is seen. Then, arranging a direction of wider visual angle of the liquid crystal display element becomes necessary. Therefore, as an embodiment, most general TN liquid crystal, in which liquid crystal molecules 13B at upper side and lower side are twisted 90 degrees each other, was adopted; and normally white display mode was formed by intercrossing each of an absorption axis of 10A, 15A of absorption type polarized light selection layers 10, 15, normally each other; and arranging each of liquid crystal molecule orientation direction of upper side 13A and lower side 13B as shown in FIG. 27. The electric

field applied to the liquid crystal layer 13 is omitted in the drawing, but the electric field was controlled by applying voltage to transparent electrodes at upper side and lower side of the liquid crystal layer. The direction of wide visual angle having no gradation reversal with obliquely incident light and small contrast ratio decrease 40A was arranged in the direction perpendicular to the drawing of FIG. 1, and the direction of narrow visual angle having gradation reversal and large contrast ratio decrease 40B was arranged in the direction lateral to the drawing of FIG. 1. As the result, in the lateral direction of the drawing FIG. 1, any color mixing of images was not observed because the illumination device had a directivity in the lateral direction, and a display having wide visual angle could be realized because the light was diffused by the upper light scattering layer 11. On the other hand, in spite of the illumination device does not have any directivity and the light scattering layer 11 does not have any diffusivity in perpendicular direction, a display of wide visual angle could be realized in the perpendicular direction of the drawing FIG. 1.

[0055]

Next, the liquid crystal molecules 13B of initial parallel orientation shown in FIG. 28 were applied to an in-plane switching display mode in which orientation of liquid crystal molecules 13B was controlled by the lateral electric field 26. The structure was formed by intercrossing the absorption axes 10A, 15A of the absorption type polarized light selection layers 10, 15 normally each other, and arranging the orientation direction 13A, 13C of the liquid crystal molecules 13B as indicated in the figures. In accordance with the in-plane switching display mode, 40D is slightly changed to blue color direction, and 40C is slightly changed to yellow color direction, but no gradation reversal is generated. Accordingly, although depending on arrangement of the

reflection type color selection layer 30 and the reflection type polarized light selection layer 31, the direction 40C whereat change of color could be reduced as possible was selected as the direction of wide visual angle, and the direction 40D whereat characteristics were varied depending on up and down direction by pre-tilting of the liquid crystal molecules 13B was selected as the direction of narrow visual angle. The perpendicular direction to the drawing FIG. 1 was designated as 40C, and the lateral direction was designated as 40D. As the result, the lateral direction of the drawing FIG. 1 had no color mixing because of the directivity of the illumination device, and display of wide visual angle could be realized because of diffusivity at the upper light scattering layer 11. On the other hand, a wide visual angle display could be realized in in the perpendicular direction of the drawing FIG. 1, in spite of the illumination device had no directivity and the upper light scattering layer 11 had no diffusivity in the perpendicular direction.

[0056]

Next, homogeneous orientation having a positive dielectric anisotropy shown in FIG. 29 (or, homeotropic orientation having a negative dielectric anisotropy) was applied to the liquid crystal display element. The direction where the liquid crystal molecules 13B uprise (or fall down) had a narrow visual angle, because orientation of the liquid crystal molecules are controlled by the electric field, and then the direction was selected as the narrow visual angle direction 40F. And the direction intercrossing normally with the above direction was selected as the wide visual angle direction. The direction perpendicular to the drawing FIG. 1 was designated as 40E, and the lateral direction was designated as 40F. As the result, the lateral direction of the drawing FIG. 1 had no color mixing because of the directivity of the illumination device, and display of wide visual angle

could be realized because of diffusivity at the upper light scattering layer 11. On the other hand, a wide visual angle display could be realized in the perpendicular direction of the drawing FIG. 1, in spite of the illumination device had no directivity and the upper light scattering layer 11 had no diffusivity in the perpendicular direction.

[0057]

Hitherto, the embodiments of the scattering layer having uniaxial or all azimuth direction scattering property and the liquid crystal display element having a visual angle dependency based on azimuth direction were explained. However, each of the above members can be used by combination of each other. In accordance with the present embodiments, a cholesteric layer was used as the embodiments of reflection type color selection layer and the reflection type polarized light selection layer, but as described in THE OPERATION, a dielectric multi-layered film, or any member operating same can be used.

[0058]

[Advantages of the invention]

As explained above, in accordance with the present invention, in order to eliminate color mixing and unclearness, which become problems when improvement of light utilization efficiency is aimed at by using a reflection type color selection means and polarized light selection means, the color selection means is formed in a stripe shape, a directivity is provided at least a direction perpendicular to the stripe direction; preferably, visual angle characteristics can be improved by using an absorption type polarized light selection means and an absorption type color selection means, and clear display with a wide visual angle can be obtained by making light be diffused after transmitting through the liquid crystal display element only in the direction where the directivity is existed.

[Brief description of the drawings]

[FIG. 1]

A cross sectional view of the liquid crystal display device showing an embodiment of the present invention.

[FIG. 2]

A cross sectional view of the liquid crystal display device for explaining its operation.

[FIG. 3]

A cross sectional view of the liquid crystal display device for explaining its operation.

[FIG. 4]

A perspective view showing an embodiment of illumination device of the present invention.

[FIG. 5]

A cross sectional view showing an embodiment of illumination device of the present invention.

[FIG. 6]

A perspective view showing an embodiment of illumination device of the present invention.

[FIG. 7]

A perspective view showing an optical member applied to the illumination device of the present invention.

[FIG. 8]

A perspective view showing an embodiment of illumination device of the present invention.

[FIG. 9]

A perspective view showing an optical member applied to the illumination device of the present invention.

[FIG. 10]

A cross sectional view showing an embodiment of illumination device of the present invention.

[FIG. 11]

A cross sectional view showing an embodiment of illumination device of the present invention.

[FIG. 12]

A cross sectional view showing an embodiment of color liquid crystal display device of the present invention.

[FIG. 13]

A cross sectional view showing an embodiment of color liquid crystal display device of the present invention.

[FIG. 14]

A cross sectional view showing an embodiment of color liquid crystal display device of the present invention.

[FIG. 15]

A perspective view showing an optical member applied to an embodiment of color liquid crystal display device of the present invention.

[FIG. 16]

A perspective view showing an embodiment of color liquid crystal display device of the present invention.

[FIG. 17]

A perspective view showing an optical member applied to an embodiment of color liquid crystal display device of the present invention.

[FIG. 18]

A perspective view showing an embodiment of color liquid crystal display device of the present invention.

[FIG. 19]

A perspective view showing an optical member applied to an embodiment of color liquid crystal display device of the present invention.

[FIG. 20]

A cross sectional view showing an optical member applied to an embodiment of color liquid crystal display device of the present invention.

[FIG. 21]

A graph showing one of characteristics of color liquid crystal display device of the present invention.

[FIG. 22]

A graph showing one of characteristics of color liquid crystal display device of the present invention.

[FIG. 23]

A graph showing one of characteristics of color liquid crystal display device of the present invention.

[FIG. 24]

A graph showing one of characteristics of color liquid crystal display device of the present invention.

[FIG. 25]

A cross sectional view showing an embodiment of color liquid crystal display element of the present invention.

[FIG. 26]

A cross sectional view showing an embodiment of color liquid crystal display element of the present invention.

[FIG. 27]

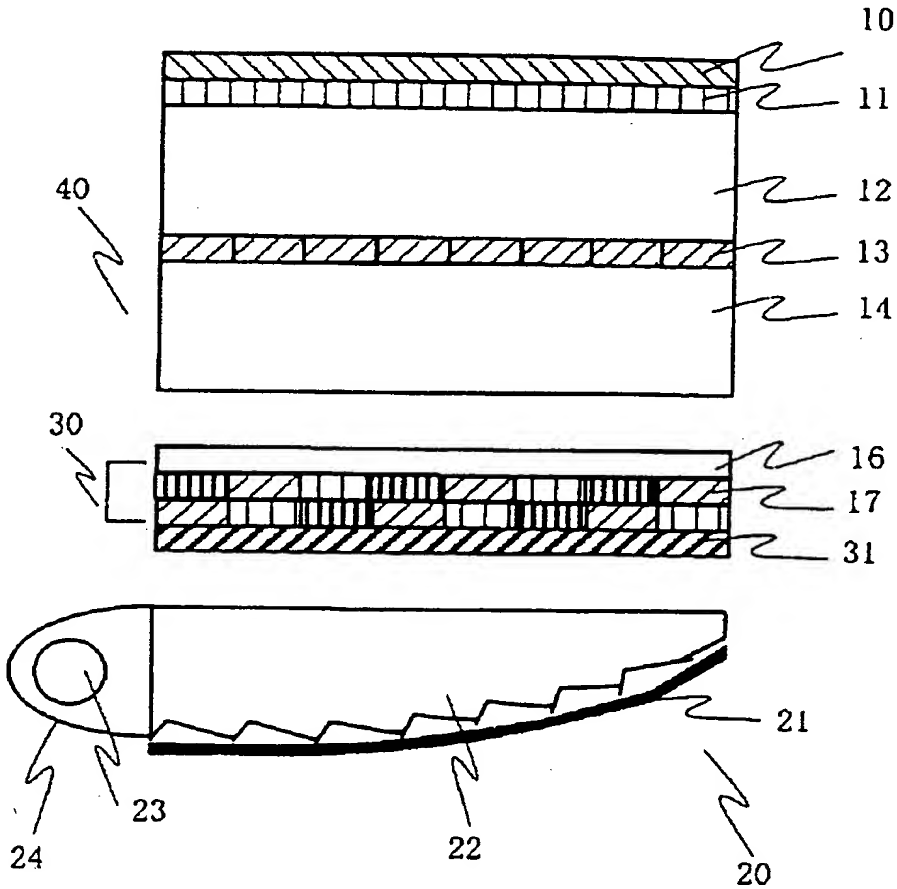
A perspective view showing an embodiment of color liquid crystal display element of the present invention.

[FIG. 28]

[Name of document] Drawings

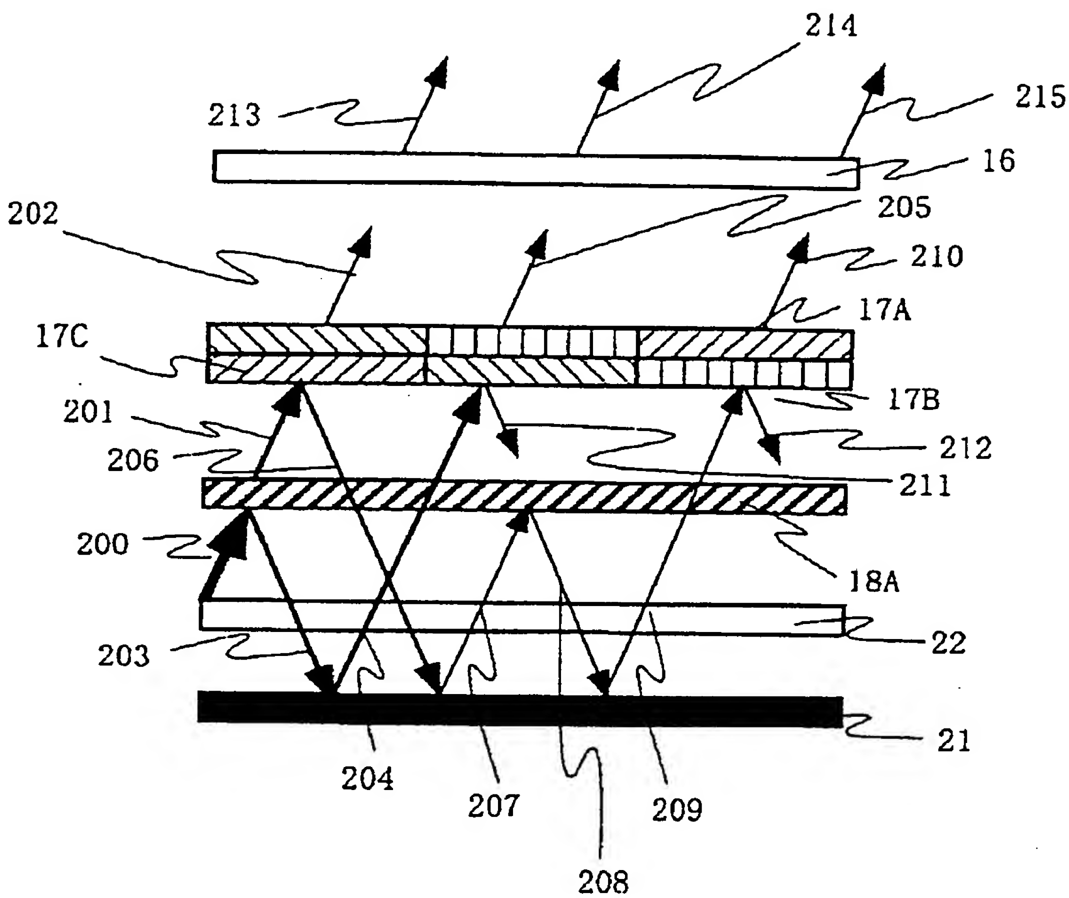
[FIG. 1]

FIG. 1



[FIG. 2]

FIG. 2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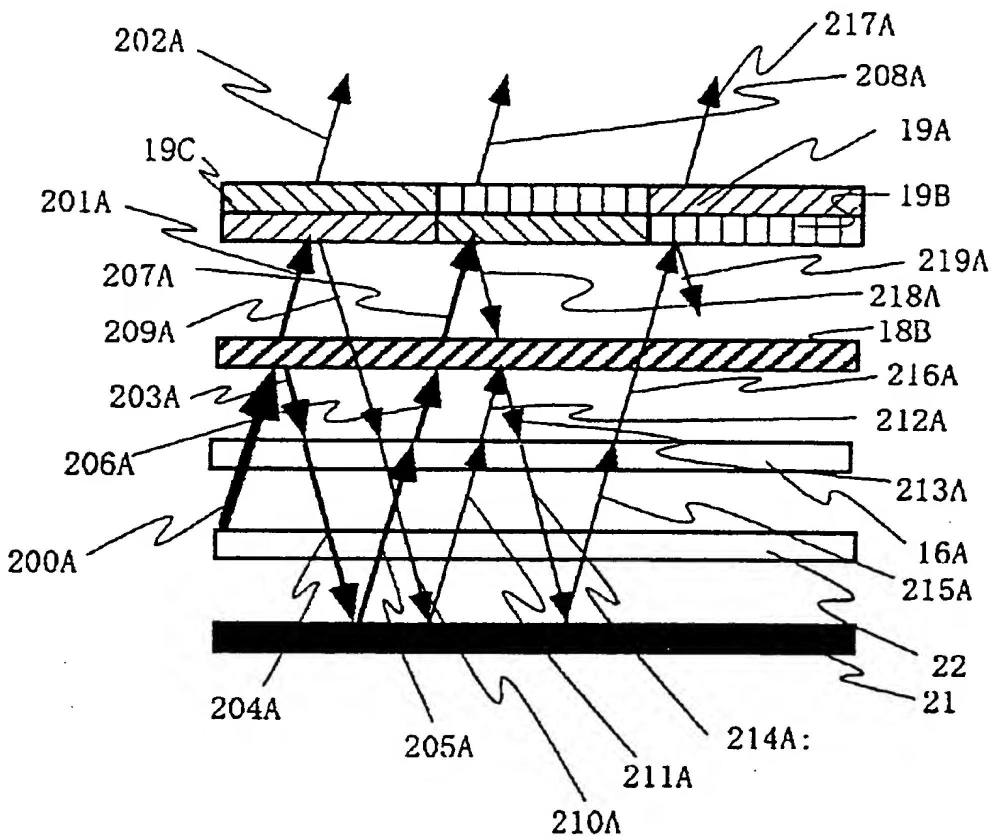
213
215
16
202
205
210
17A
17C
17B
201
212
206
211
200
18A
22
203
21
204
207
209
208

[FIG. 3]

FIG. 3


202A
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208A
19A
19C
19B
201A
219A
207A
218A
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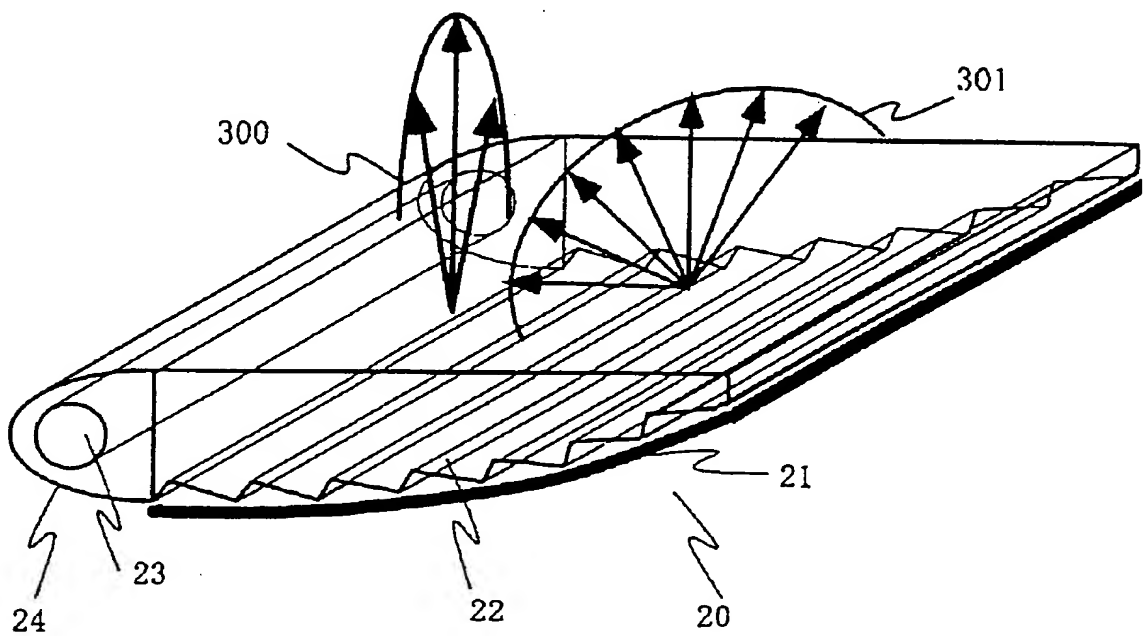
18B
216A
203A
212A
206A
213A
16A
200A
215A
22
21
204A
205A
214A
211A
210A

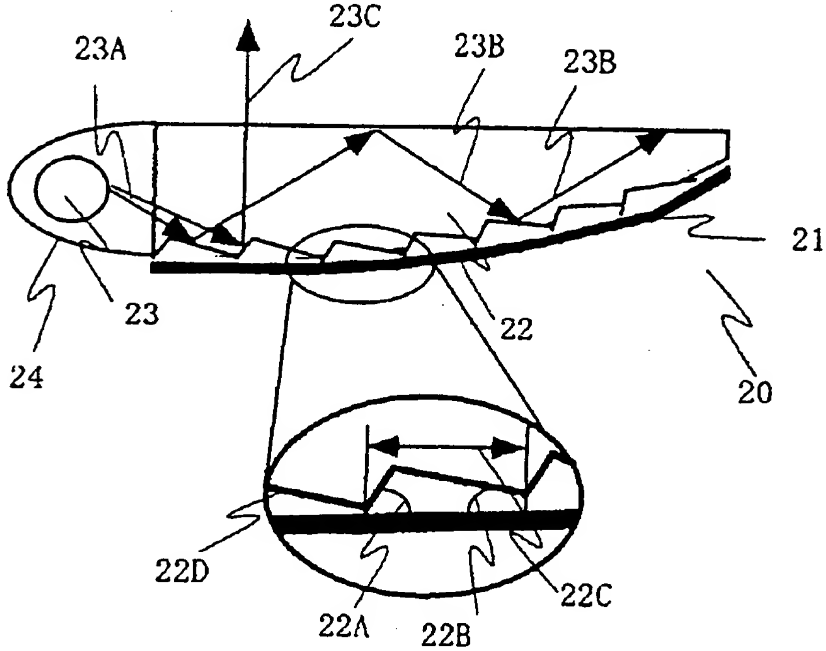
[FIG. 4]

FIG. 4



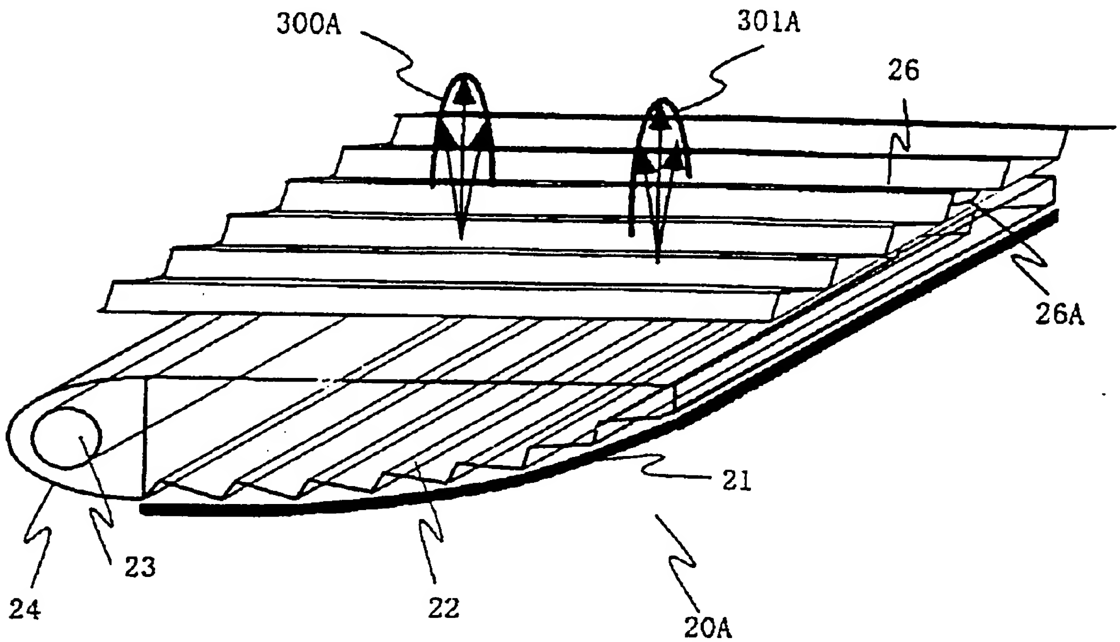
[FIG. 5]

FIG. 5



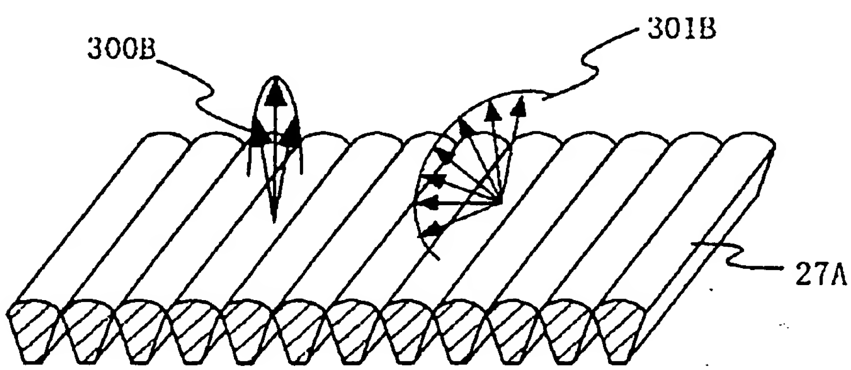
[FIG. 6]

FIG. 6



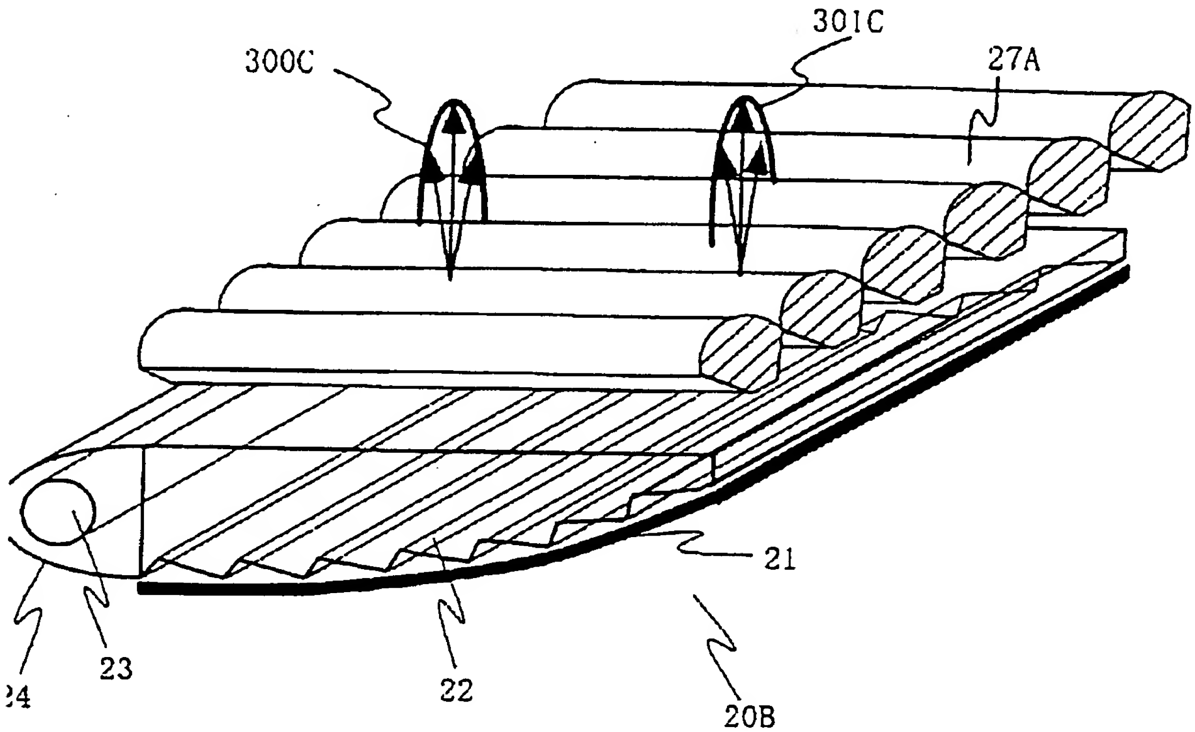
[FIG. 7]

FIG. 7



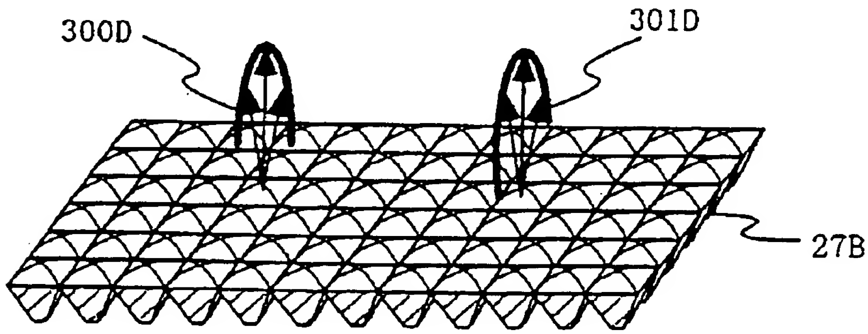
[FIG. 8]

FIG. 8



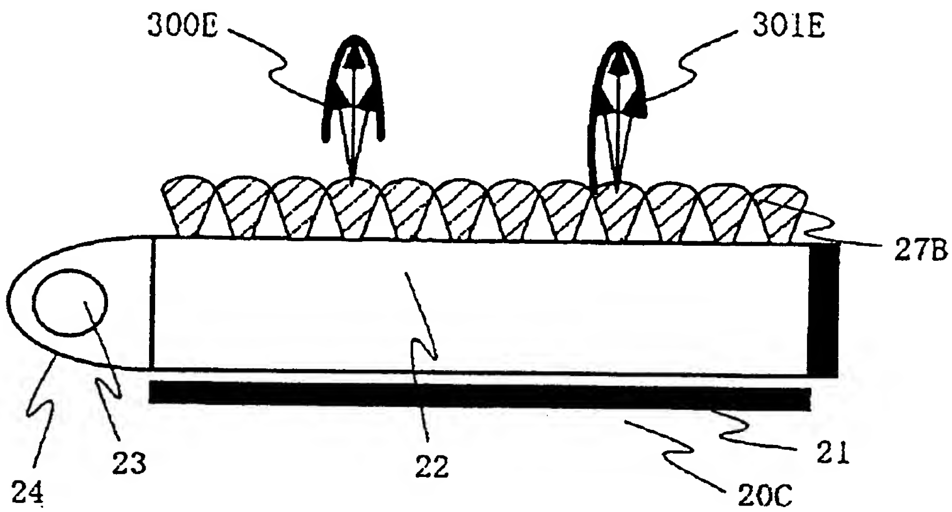
[FIG. 9]

FIG. 9



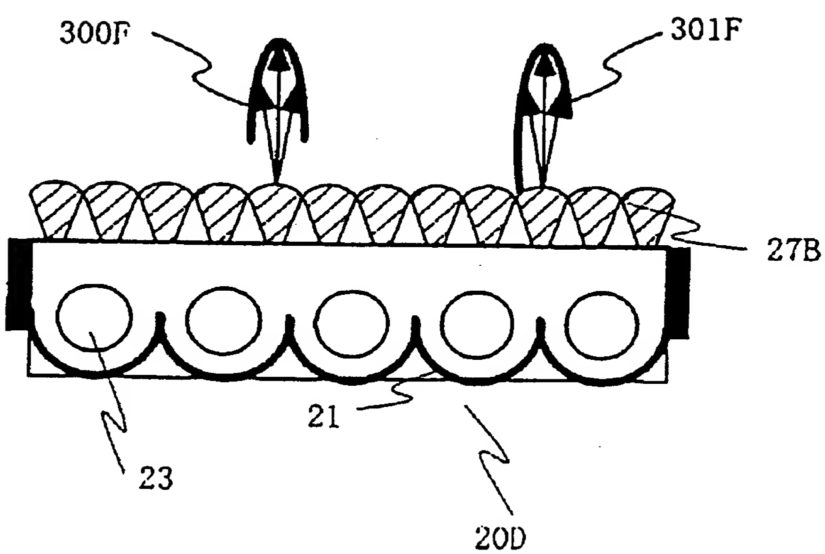
[FIG. 10]

FIG. 10



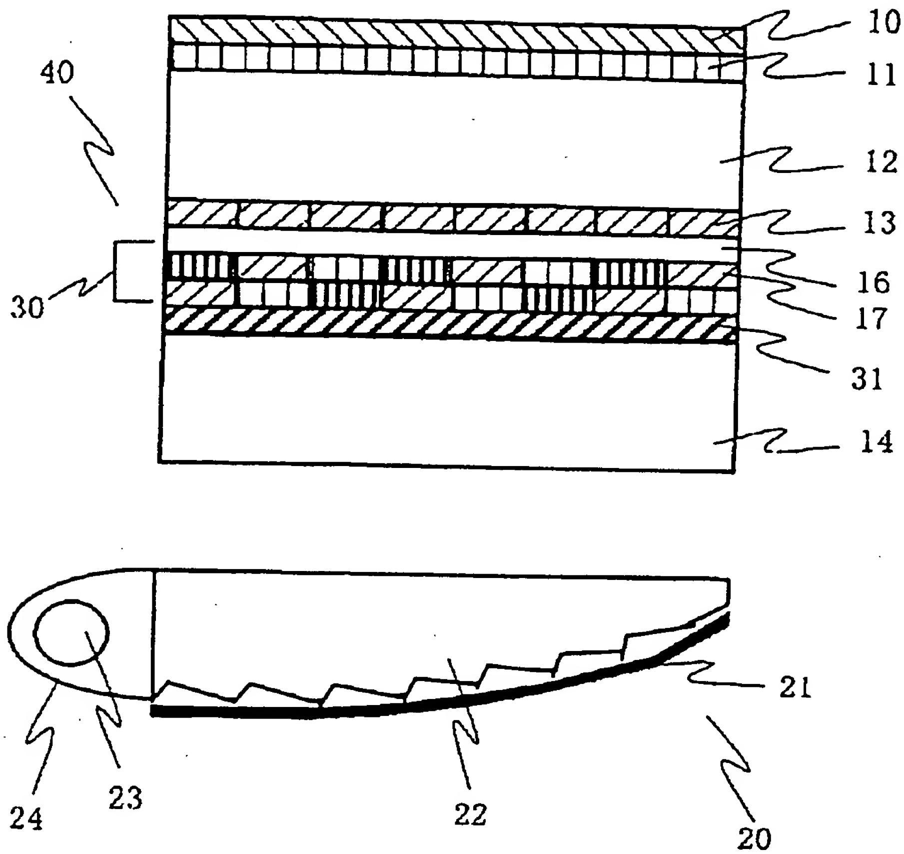
[FIG. 11]

FIG. 11



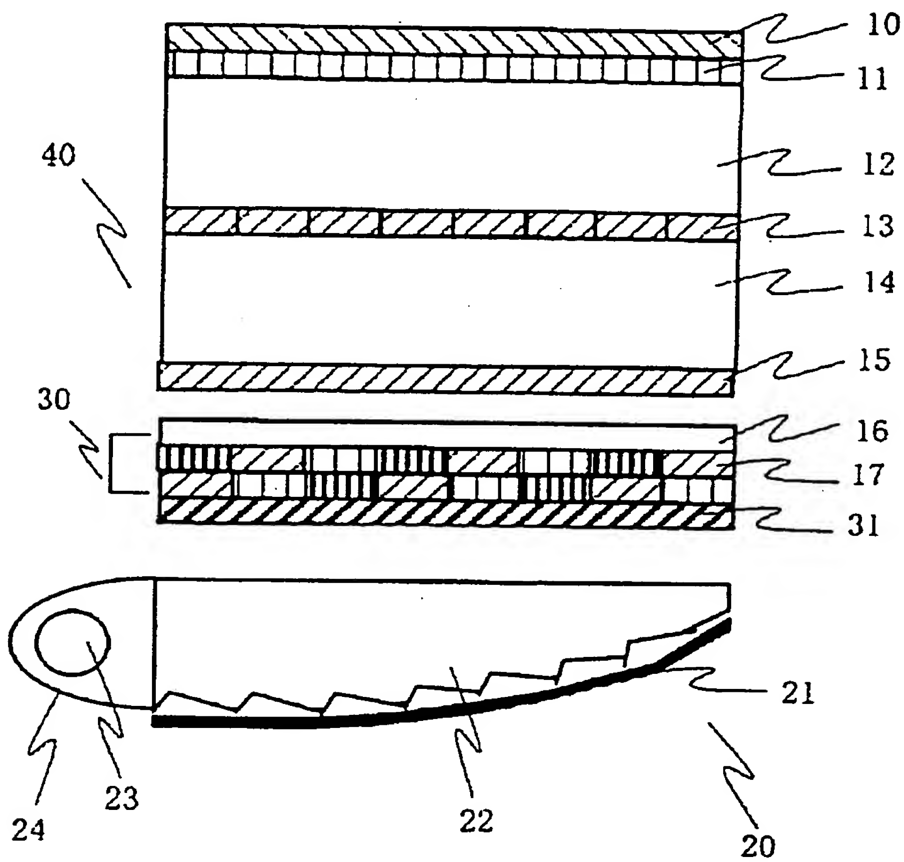
[FIG. 12]

FIG. 12



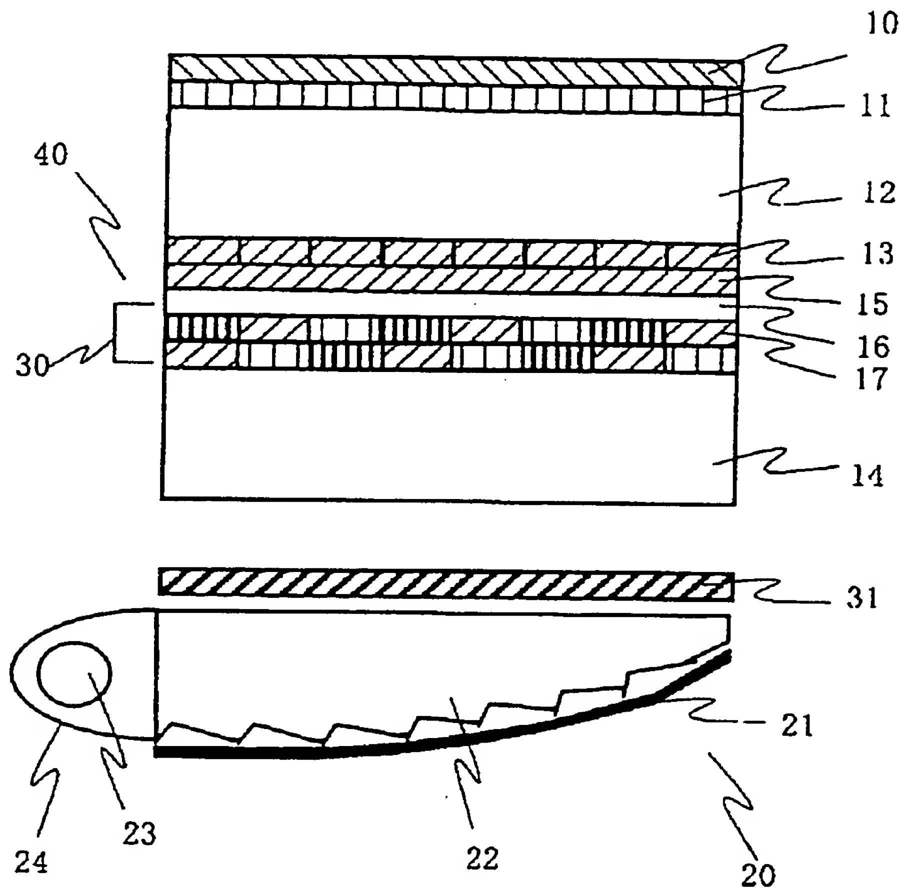
[FIG. 13]

FIG. 13



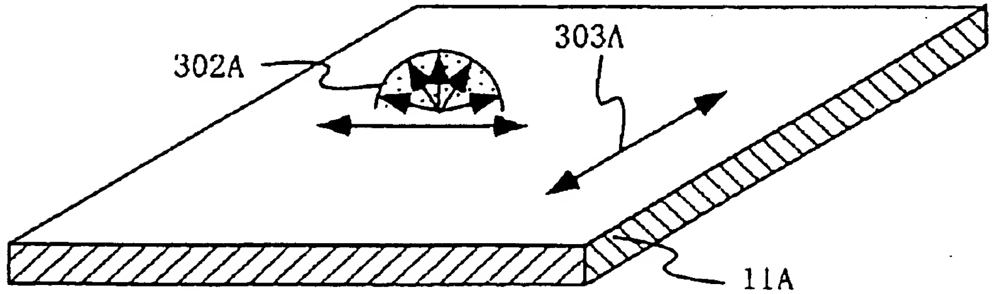
[FIG. 14]

FIG. 14



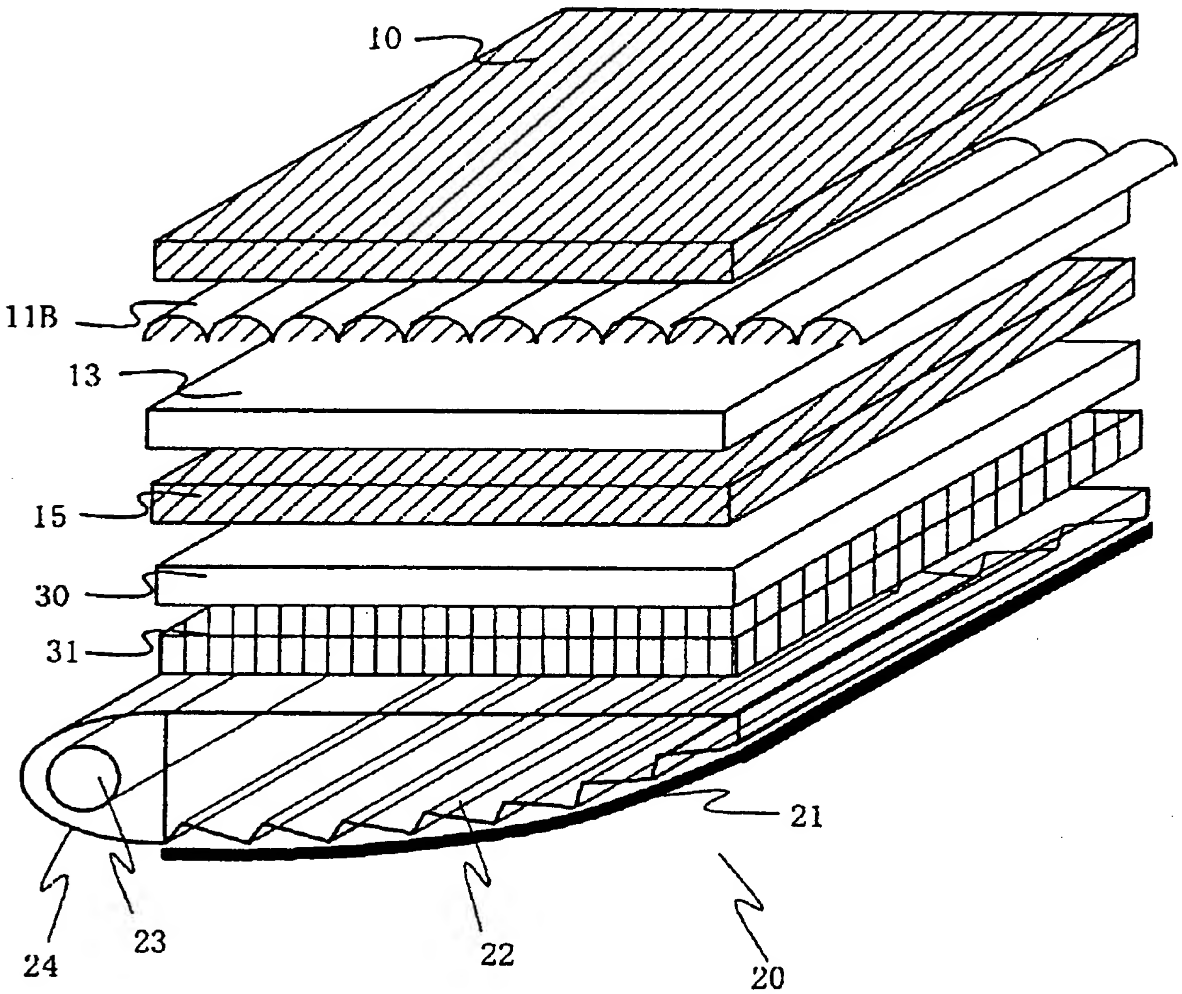
[FIG. 15]

FIG. 15



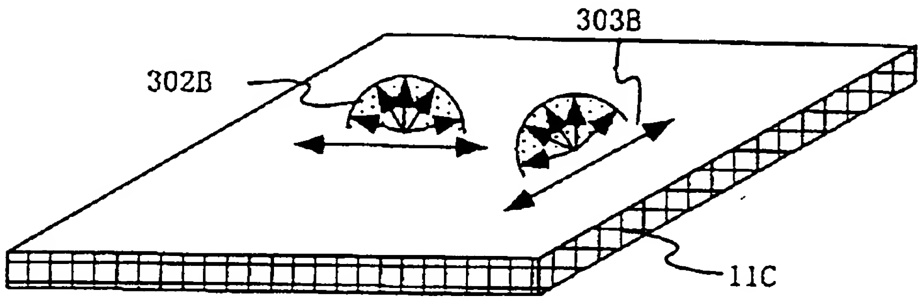
[FIG. 16]

FIG. 16



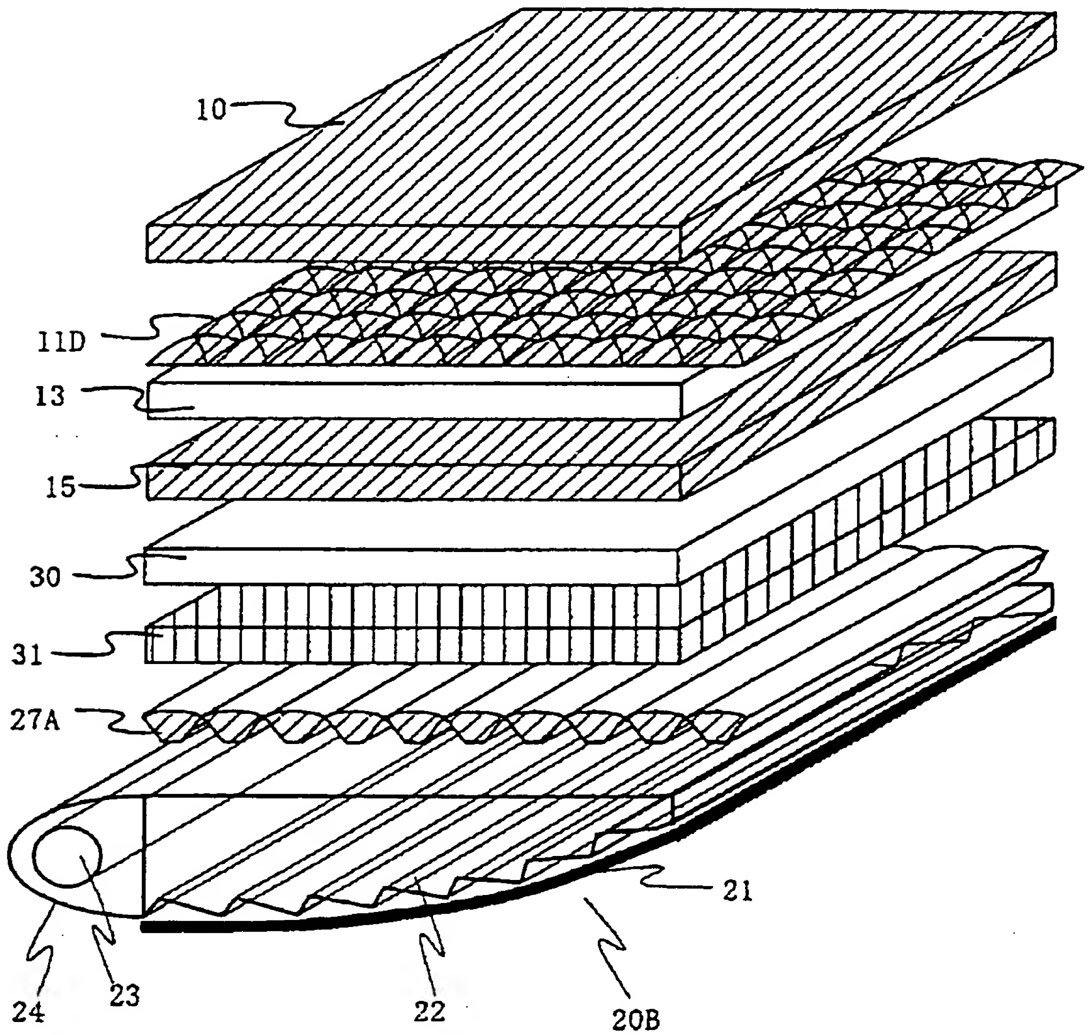
[FIG. 17]

FIG. 17



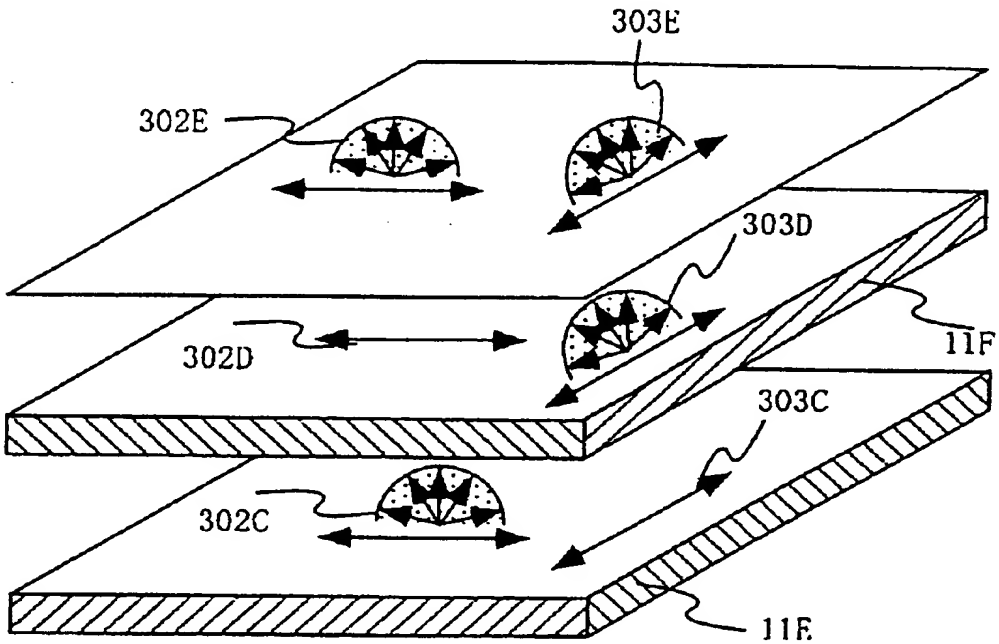
[FIG. 18]

FIG. 18



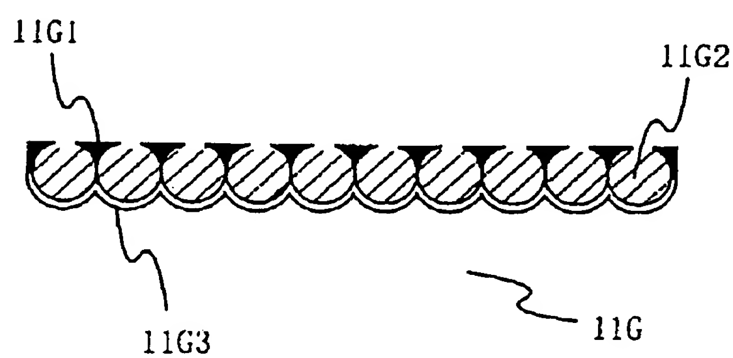
[FIG. 19]

FIG. 19



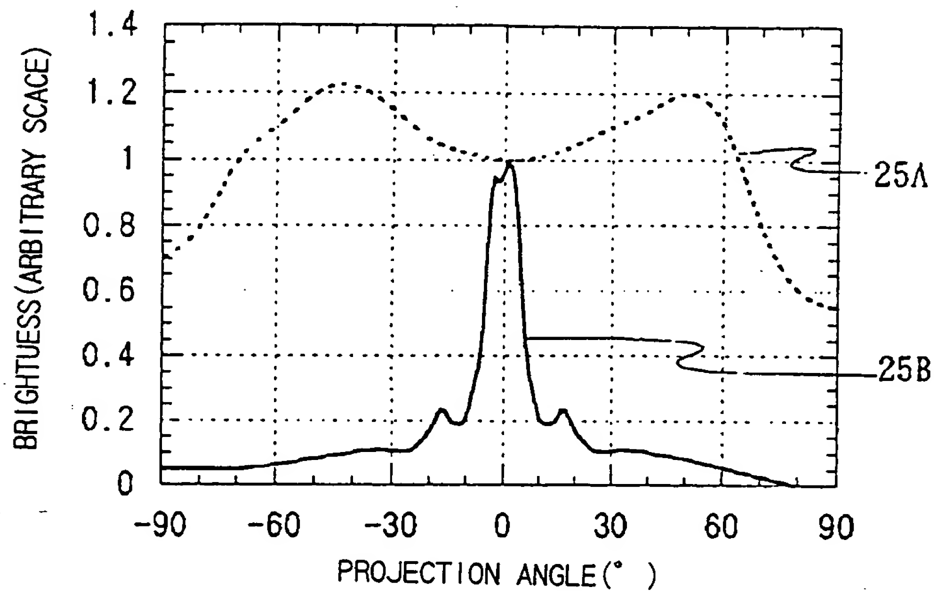
[FIG. 20]

FIG. 20



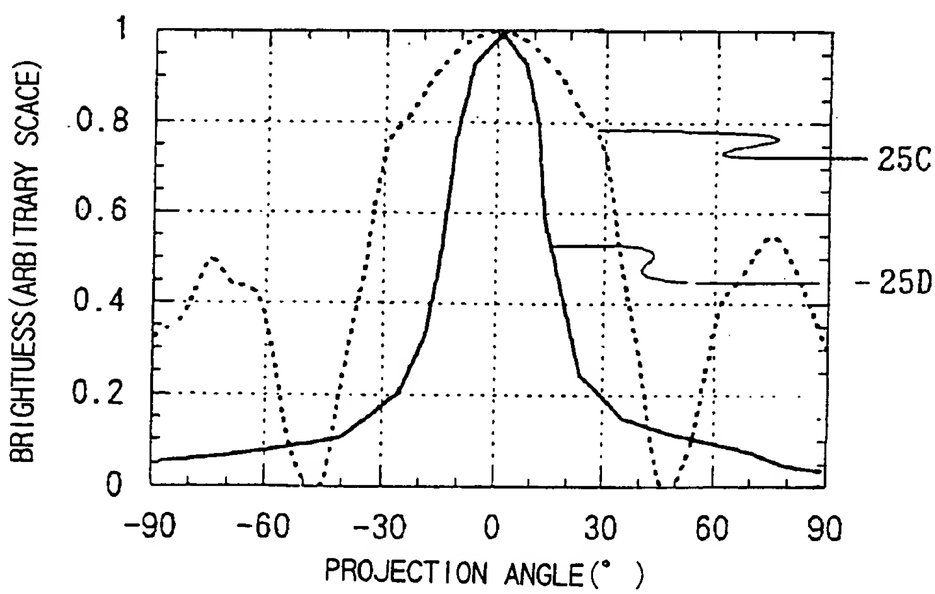
[FIG. 21]

FIG. 21



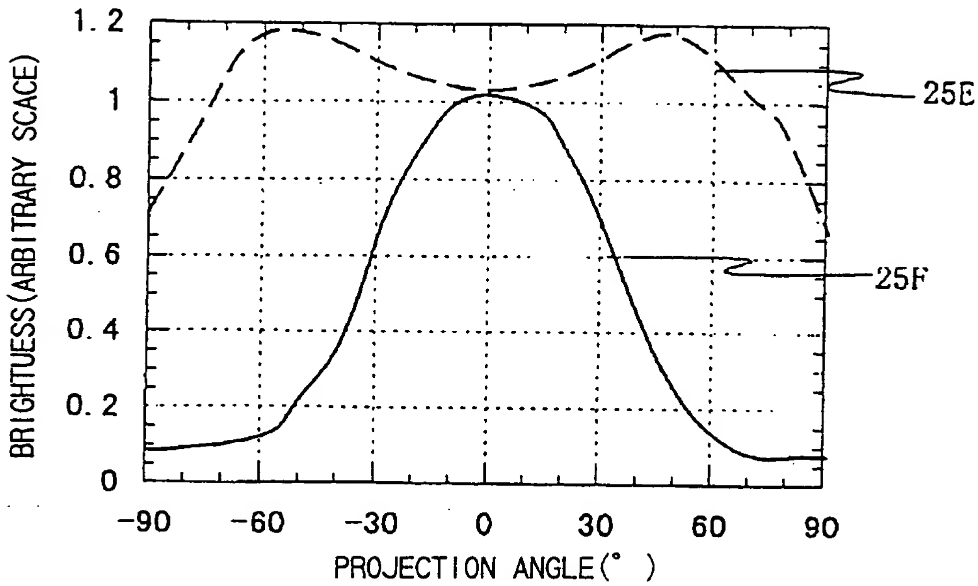
[FIG. 22]

FIG. 22



[FIG. 23]

FIG. 23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0.8
0.6
0.4
0.2
0
BRIGHTUESS(ARBITRARY SCACE)
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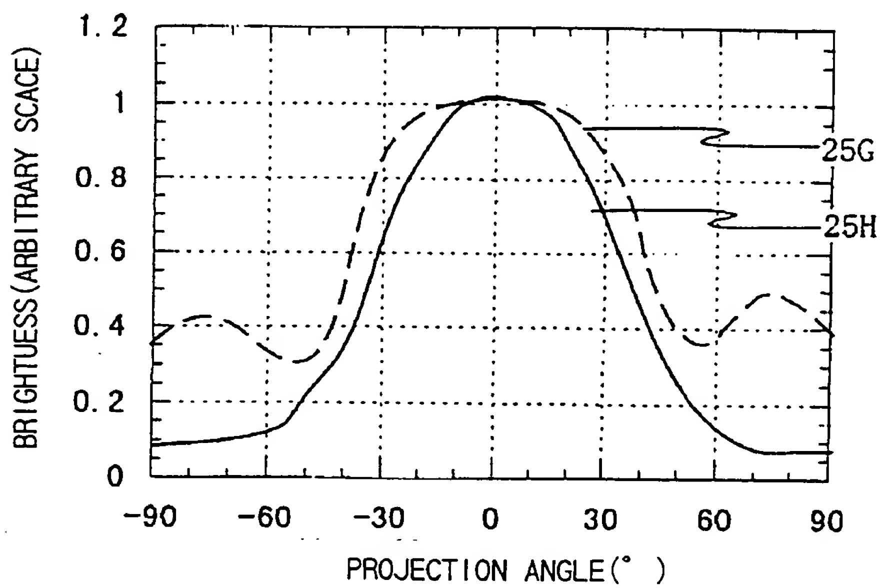
-60
-30
0
30
60
90
PROJECTION ANGLE(°)
25E
25F

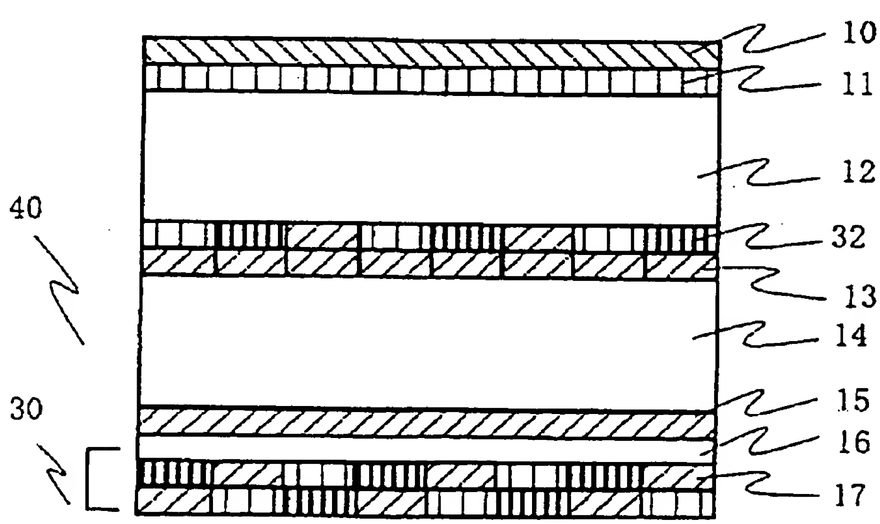
[FIG. 24]

FIG. 24



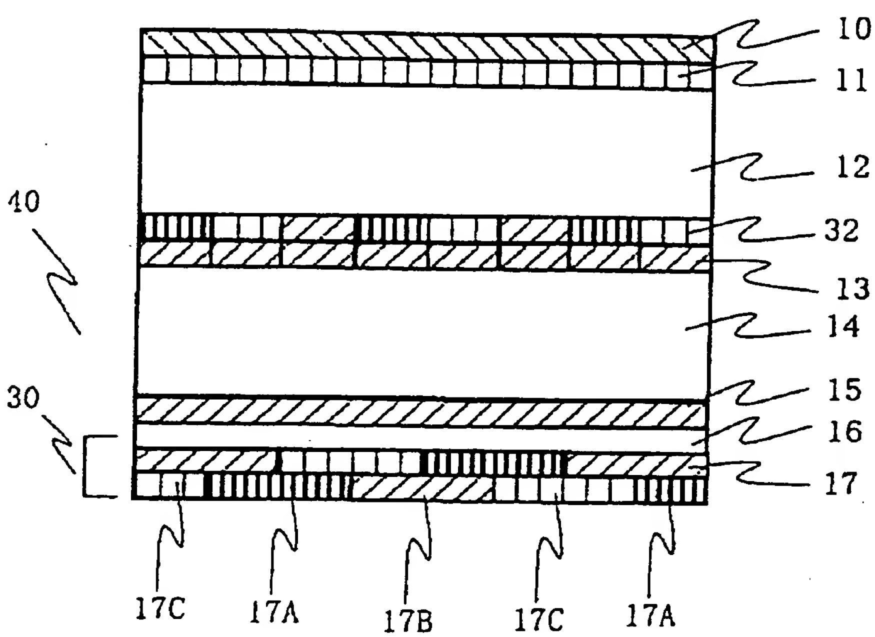
[FIG. 25]

FIG. 25



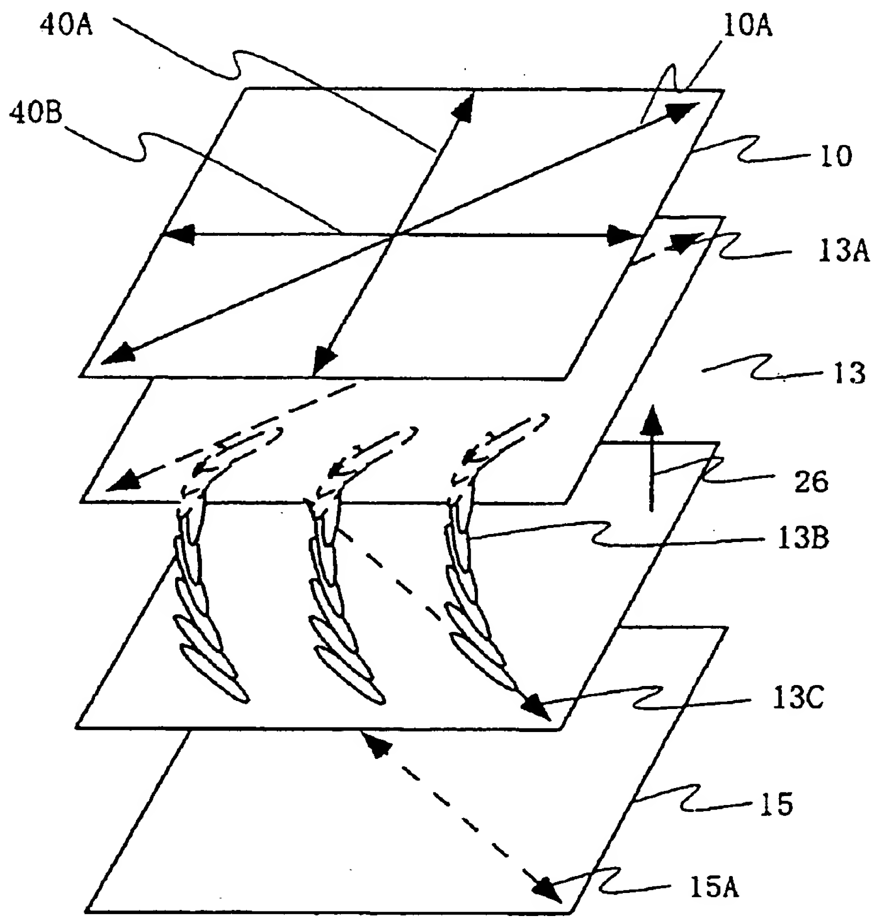
[FIG. 26]

FIG. 26



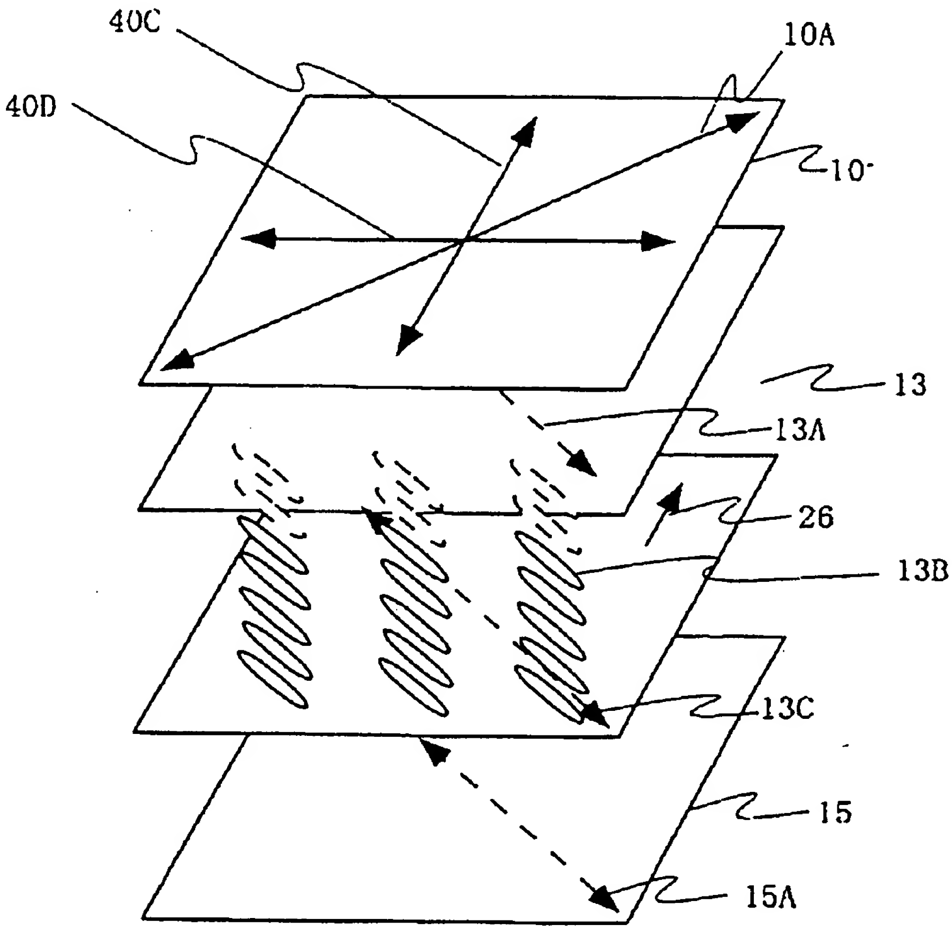
[FIG. 27]

FIG. 27



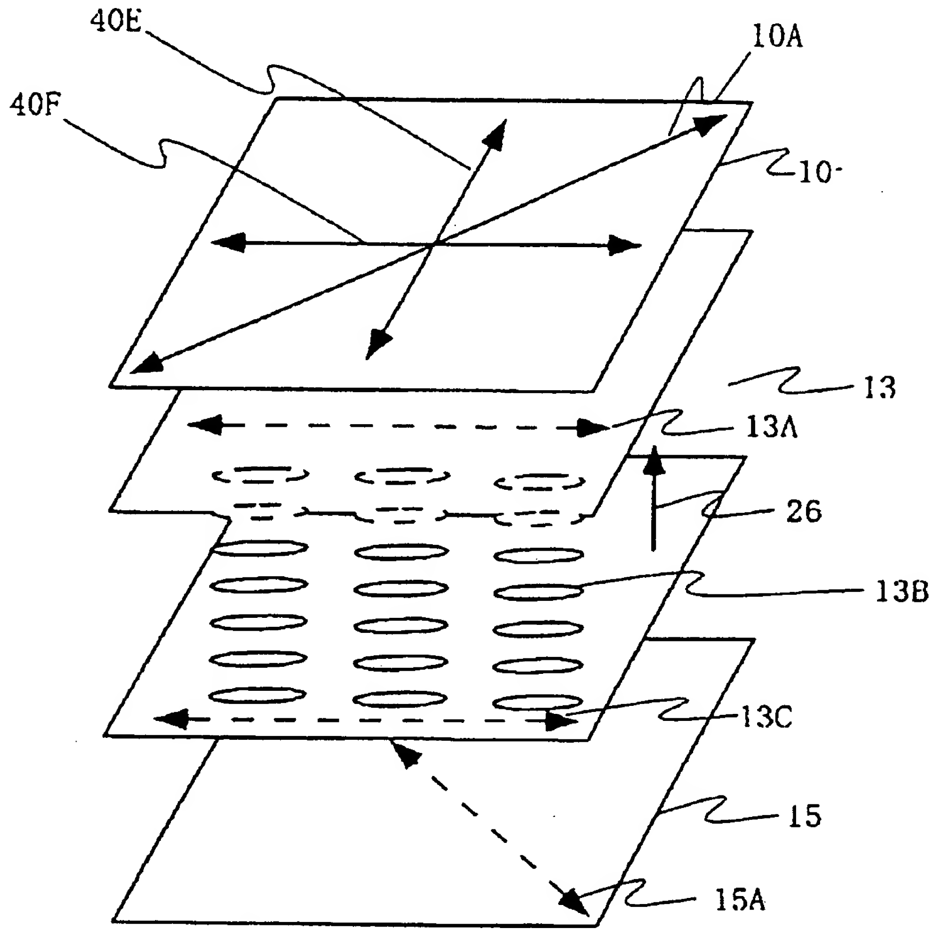
[FIG. 28]

FIG. 28



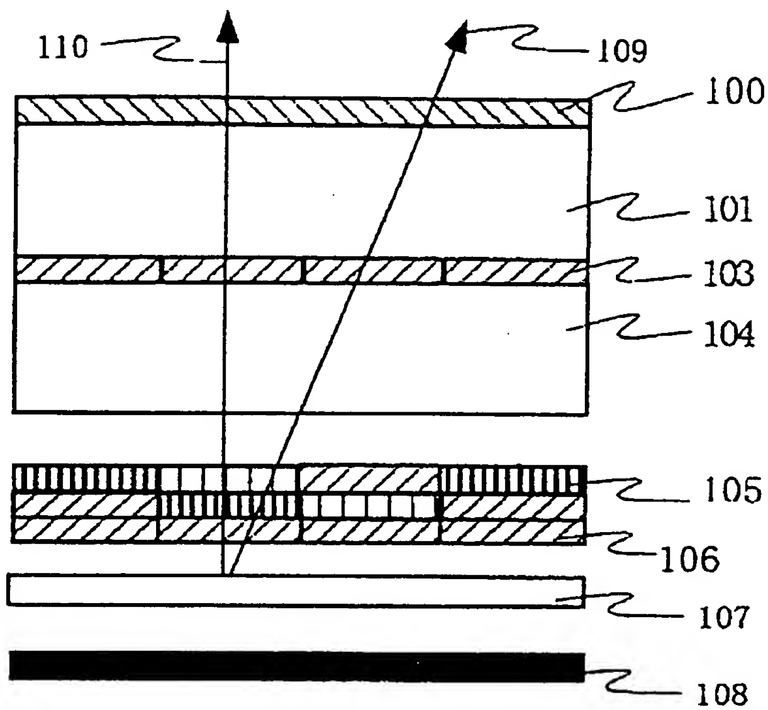
[FIG. 29]

FIG. 29



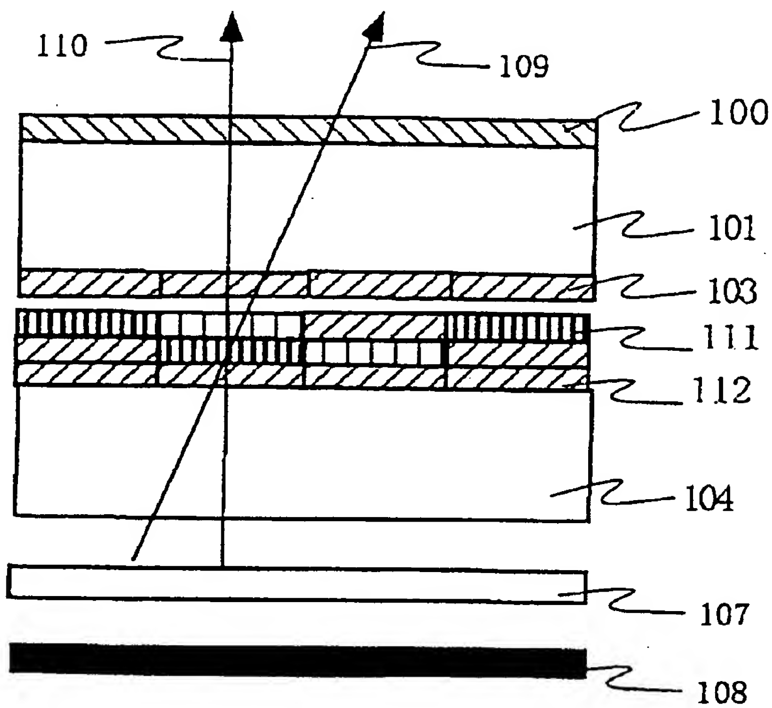
[FIG. 30]

FIG. 30



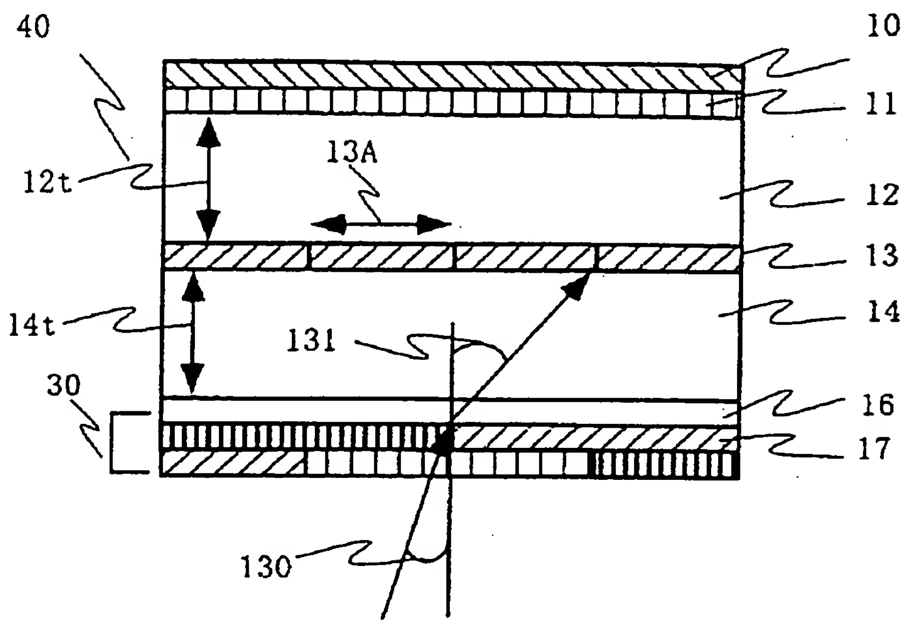
[FIG. 31]

FIG. 31



[FIG. 32]

FIG. 32



[Name of document] Abstract of description

[Abstract]

[Issues]

Aiming at improving light utilization efficiency by eliminating absorption loss by the polarized and color filter, problems such as unclearness of images, color change depending on visual angle, contrast decrease, and the others which are generated when a reflection type color selection means, and a reflection type polarized light selection means are applied are suppressed, and clear images will be obtained with wide visual angle.

[Means to solve the problems]

A liquid crystal display device comprising an illumination device which comprises a reflection type color selection means and a reflection type polarized light selection means: wherein the reflection type color selection means is made a stripe shape; the illumination device has a directivity at least in a direction intercrossing normally with the stripe; and an uniaxial light diffusing means having a diffusivity at least in a direction intercrossing normally with the stripe is arranged at displaying plane of a liquid crystal display element. Furthermore, the display mode is made to have a wide visual angle in the direction of the stripes.

[Selected drawing] FIG. 1